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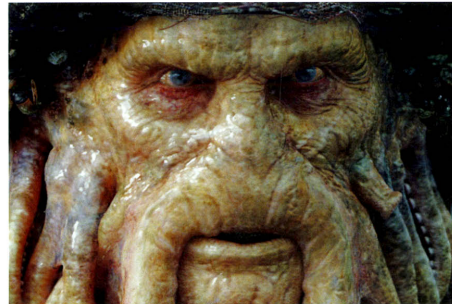
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Overview

John Scheele on World Trade Center

Article by Jody Duncan

As the most photographed 100 years in history, the 20th century was captured in many evocative film images: The mushroom cloud of an atomic bomb test illuminating the white-sand deserts of New Mexico; American astronauts setting foot on the moon; a naked Vietnamese girl running from the horrors of war; the space shuttle Challenger exploding in midair — to name but a few.

The ubiquitous nature of digital photography — so commonplace that every cell phone can now capture images for posterity — promises an even more definitive visual record of the 21st century. Although 93 years remain before that century is played out — 94 for numerical sticklers — it is difficult, and even a bit unsettling, to imagine that they will yield more dramatic or soul-searing images than those surrounding the events of September 11, 2001.

Commercial jetliners flying into the twin towers of the World Trade Center, flame and smoke issuing from the upper stories, the towers collapsing in a cataclysmic cloud of dust and debris, the smoking ruins that defined a new and ghastly *Manhattan* skyline — all of these images imprinted themselves, irrevocably, on the hearts and minds of everyone who saw them.

Re-creating some of those horrific images was among the filmmaking challenges of Oliver Stone's *World Trade Center*, which recounts the terrorist attack and its aftermath from the intimate perspectives of Port Authority police officers John McLoughlin (Nicolas Cage) and Will Jimeno (Michael Peña), two of only 20 survivors rescued from the rubble of *Ground Zero*. "What drew all of us to this project," commented visual effects supervisor John Scheele, "was that it was a way to make this national disaster personal, so that we could experience it directly and really feel what happened. This isn't a film about who did it or why — that's another movie, and that would be interesting, too. This film is about what the people in the middle of it went through on that day."

Simulating the catastrophic events as seen from the perspectives of McLoughlin and Jimeno formed the heart of *World Trade Center*'s 115-shot visual effects assignment, the bulk of which was awarded to Double Negative. *Giant Killer Robots* and *Animal Logic* also made significant



contributions, while Proof produced previzualizations to help determine shot choreography and live-action requirements.

Production shot live-action on sets built at the old Hughes Aircraft facility in Playa Vista, as well as in New York and New Jersey, often in the actual homes and workplaces in which the real people had played out the events of that day. Initially, Stone's quest for authenticity had led him to consider shooting at the actual *Ground Zero* site, as well. "That site was still largely open," observed Scheele, "and so we could have filmed in that area. But as everyone thought it through, it became clear that it was a bad idea. People in New York would have been traumatized to see our actors there, all bloodied up, with dust and debris blowing everywhere, just as it did that day. We made the decision not to shoot there — at least, not with the practical effects going on — very early in the planning stages of the movie."

Stone subsequently considered shooting clean plates at the site — without the practical dust and debris that would spur disturbing memories — then adding photorealistic atmospherics through digital effects. To determine if such an approach could be convincing, Scheele commissioned Double Negative to produce a series of tests. "It was very important to Oliver that none of the CGI effects look artificial — what he always described as 'shiny.' If we were going to be adding in digital dust and debris, he wanted to make sure that it would look absolutely real. Double Negative visual effects supervisor Mike Ellis created tests that confirmed we could shoot the World Trade Center site clean, and then add dust and debris that didn't look artificial." In the end, the filmmakers judged that shooting even clean plates at *Ground Zero* was ill-advised. Instead, production built greenscreen sets encompassing *Manhattan's* Church and Vesey Streets in Los Angeles. "We still shot at the Port Authority Bus Terminal and at other locations in New York; but anything below Canal Street was off-limits."



The September 11, 2001, terrorist attacks on New York are recounted through the eyes of two Port Authority police officers in Oliver Stone's World Trade Center. Visual effects supervisor John Scheele collaborated with Double Negative, Animal Logic and Giant Killer Robots to produce effects shots that would recall the day's horrific images. In an opening montage establishing the Manhattan skyline as it appeared early on the morning of the attacks, Double Negative nestled the World Trade Center's twin towers into live plates, computer modeling the structures using original blueprints.

Among the shots photographed on location were those featured in an opening montage, set early on the morning of September 11, as McLoughlin and Jimeno commute to work. "The montage shows the city as it looked before the attacks. You see the towers as they stood that morning, before they were hit. They were all meant to look like natural shots, but they involved some of the most beautiful effects work done by Double Negative, which added the towers to live-action plates of New York shot by our second unit."

McLoughlin and Jimeno arrive at the Port Authority police station that morning unaware that, within minutes, the crashing of two commercial airliners into the World Trade Center will transform a routine workday into an extraordinary 24-hour fight for survival. In keeping with the

subjective narrative approach, World Trade Center features no shots of the planes actually striking the towers, as neither Jimeno nor McLoughlin witnessed those events personally. “Nobody in this group of people the film follows actually saw the planes hit. Will Jimeno was out on patrol in front of the Port Authority station, helping some tourists who were asking for directions, and he heard the sound that so many people later spoke of — the sound of a jet flying very low. He also saw the shadow of the plane going over; and so, we see that in the movie.” Ron Frankel at Proof worked out the trajectory of the plane’s shadow, which Double Negative then added to the live-action as a CG effect.

The men observe the results of the planes’ impacts when — dispatched to the Trade Center to help evacuate people from the burning towers — the officers get their first live, non-televised look at the damaged buildings en route. Rather than up-rez television camera footage of the burning towers that had been broadcast around the world, the filmmakers commissioned Double Negative to re-create the view with absolute veracity. “The unique problem of this film was that there has never been a visual historical event that is so well known across the world. Everyone knows what those burning towers looked like. Because of that, we started out thinking that we wouldn’t need any shots looking up at the towers. We thought it would be more effective and more powerful to just put the camera on the men looking up at the towers, and capture their expressions and reactions.”



Port Authority police officers – called to the World Trade Center after a jet airliner has struck one of the towers – get their first live glimpse of the damaged structure en route. Rather than up-rez television news footage of the burning landmark, Stone and Scheele tasked Double Negative with re-creating the familiar image using a separate post-attack tower model. To create photorealistic smoke issuing from the structure, Double Negative upgraded its voxel renderer to efficiently handle a wide variety of fluid smoke simulations.

Later, Stone and his collaborators realized that for audience members to experience what McLoughlin and Jimeno were experiencing, they had to see what they were seeing. “The view of the buildings burning was part of revealing what was going on in the men, emotionally. Looking up and seeing those twin towers burning was part of these men’s experience, and it seemed essential to see that, from their eyes.”

To depict the men’s point of view from the street, and later from the base of the towers when they arrive at the World Trade Center, Double Negative created CG structures expelling simulated fire and smoke. “For these shots, Pete Bebb and Ryan Cook at Double Negative referenced both television footage and video coverage that was shot by regular people on the streets. They sought to re-create the emotional feeling in those shots, but also intensify them and bring them up to a higher level. With cinematic effects of scale and sound, these shots really put you there and move you very deeply.”

In reality, the officers, upon their arrival at the World Trade Center, not only saw the tower damage up close, they also witnessed the terrible spectacle of people, trapped in the inferno seventy or more stories above the ground, jumping and falling to their deaths. Of all the issues raised by a film

about 9/11, none was more sensitive than how much of that horror — if any — should be re-created. Stone ultimately chose to incorporate into the film a single shot of a falling figure. “Again, it came down to a matter of the audience experiencing what John and Will had experienced. These images were terrible, but they were important because they cut to the hearts of the police officers that arrived there to help. Oliver wrestled with this issue throughout the making of the movie, and the refinement of this shot continued right to the end.”

Rather than duplicate the action in the video reference, Double Negative studied select takes chosen by editor David Brenner, and then created an amalgam shot that was authentic, but not identifiably any one ‘jumper.’ “Even though it is impossible to make out the identity of anyone in the documentary footage, we didn’t want this jumper to represent someone’s actual husband or father or son. We also selected a view where the size of the falling figure was barely discernible — still intense, but not as shocking as what the men saw when it was happening right in front of them.”

Moments after making their way down to the concourse — an underground shopping center that connected the twin towers — and entering the south tower to help in the evacuation effort, the police officers hear a thunderous rumbling sound as walls begin to shake and debris begins to fall all around them. McLoughlin orders his men out of the tower lobby, and races with them through the concourse, into a vestibule near an elevator shaft. “John knew the Trade Center well, and in that split-second decided that this shaft would be the strongest support structure — and he was right. As the debris came down, a lot of it fell around them rather than on them, like branches falling around a tree stump that remains standing. The men were able to get into these small, wedge-shaped spaces, and it gave them just enough space to survive the collapse.”

Production shot the scene’s live-action on a concourse set constructed by production designer Jan Roelfs and his crew within one of the Hughes facility’s abandoned hangars. Roelfs referenced advertising brochures from concourse businesses to ensure all of the company names and graphics were accurate. “Jan matched the actual concourse very



Pummeled by falling debris as Tower 2 begins to collapse, Sergeant John McLoughlin (Nicolas Cage) and his men dash out of the building and into the adjacent concourse area. Stone shot the sequence on a concourse set backed by greenscreen. For a shot from officer Will Jimeno’s (Michael Peña) point of view, Animal Logic transformed the clean footage into a scene of violent destruction, adding a collapsing 3D tower lobby set populated with digital extras into the green matte area. Animal Logic also rebuilt the concourse in 3D, and then destroyed it piece by piece using its proprietary ‘Rubble’ tool.



Pummeled by falling debris as Tower 2 begins to collapse, Sergeant John McLoughlin (Nicolas Cage) and his men dash out of the building and into the adjacent concourse area. Stone shot the sequence on a concourse set backed by greenscreen. For a shot from officer Will Jimeno’s (Michael Peña) point of view, Animal Logic transformed

exactly in the set. To save time and money, he dressed one end as if it was looking into the lobby of the north tower; and then he redressed it to look toward the lobby of the south tower. These were huge, cathedral-like, open-air lobbies consisting of the first seven floors of the towers; but we built just a small area of the lobbies, backed with a large greenscreen. Giant Killer Robots extended the lobby sets for the scenes leading up to the collapse, and Animal Logic created CGI lobbies and the concourse itself for the actual collapse.”

The tremendous air pressure of 110 floors collapsing in less than ten seconds produces a huge pyroclastic cloud that bursts through the lobby and fills the concourse. “As horrifying as the collapse looked from the outside, as most of us saw it, it was even more terrifying for the men experiencing it from the inside. Marty Bresin, our special effects supervisor, compared the collapse to the action of a gigantic air ram. It had all the power and energy of a nuclear blast, but without the combustion.”

To develop the look of the pyroclastic cloud, Animal Logic visual effects supervisor Andy Brown and his team produced a test using fluid dynamics and particle systems. “Animal Logic’s first visuals showed the cloud of dust filling the lobby and moving through the concourse, as well as the building beginning to come apart. One of the reasons we had picked Animal Logic for this job was because of a brilliant test they produced at the beginning of the show to demonstrate what this might look like.”

Giant Killer Robots generated subsequent shots of the men’s point of view from inside the vestibule as the concourse walls disintegrate around them. During production, Bresin and his special effects crews had rigged a single column to fall and set walls to shake and vibrate to suggest the initial stages of the concourse collapse; but the collapse itself had always been planned as a visual effects sequence. “Because of the energy and force of this collapse, we knew these were effects that couldn’t

the clean footage into a scene of violent destruction, adding a collapsing 3D tower lobby set populated with digital extras into the green matte area. Animal Logic also rebuilt the concourse in 3D, and then destroyed it piece by piece. Effects artists used Maya fluid simulations in conjunction with Animal Logic’s in-house particle system to create the massive, churning ash cloud breaking through the lobby’s revolving glass doors and surging toward the men. To position one character so he would seem to be running nearer to McLoughlin, Animal Logic rotoscoped the actor out of his original placement in the shot and slipped him forward in time.



For an aerial view of the debris formed by the collapse of the towers, Double Negative started with helicopter plates shot over the current Ground Zero site and surrounding areas. Early in the film’s development, Oliver Stone and his collaborators had considered shooting key street-level scenes on location at Ground Zero, as well – an idea initially encouraged by New York City officials. Upon further reflection, the filmmakers opted to re-create the area using sets, judging that the spectacle of bloodied and ash-covered extras, smoke, fire and airborne debris would stir traumatic memories for Manhattan residents.



Double Negative removed construction equipment from the Ground Zero helicopter plate and replaced it with post-collapse destruction. To ensure accuracy, Double Negative built the debris field based on U.S. government lidar scans of the area, executed in the days following September 11. Though Double Negative modeled and hand-placed larger pieces, the effects team generated the majority of the

be done practically. Debris flying out of the lobby and into the concourse, for example, would have to fly laterally, as if it was flying outward with hurricane force. There is no way to simulate that kind of force with practical effects. So Giant Killer Robots visual effects supervisor Rich McBride created the look of radiating energy and the pyroclastic cloud blowing through the walls in CGI.”

debris pile by creating a database of different types of debris, then placing them procedurally via a particle system. Double Negative painted damage onto surrounding buildings and obscured the entire scene in a haze of CG smoke.

GKR also broke up the solid set floor around Nicolas Cage when, during postproduction, Oliver Stone decided he wanted to see John McLoughlin begin to drop through that floor to better sell the idea of structural collapse. “Giant Killer Robots was very clever in combining 2D and 3D techniques to break up the practical floor and drop the character through frame.”

In a rare departure from the subjective approach, the camera rises from the men buried beneath the rubble, drifts upward through the ground-level smoke and debris, and continues to lift above *Manhattan* — all to illustrate the cataclysmic scale of the tower collapse. “Initially, we experimented with doing this as one continuous shot, but that just seemed too contrived and synthetic. So, instead, we did a series of three pullouts that dissolve into one another.”

Proof previzd the shots using a computer model of *Manhattan* provided by EarthData. Double Negative upped the level of detail in the final shots. To create the models of *Ground Zero* — both for the pullout and for subsequent views of the debris pile — Andy Taylor and Hal Couzens of Double Negative organized a crew that spent three weeks doing extensive high dynamic range digital photography at the real *Ground Zero* site. “They shot more than 500,000 images, and that became a tremendous resource. It was similar to what they had done for *Batman Begins*, using digital photography of areas of Chicago as the basis for those digital environments. The difference here was just one of emphasis and detail. We were going to be standing right on those New York streets in this film, and the details of what those streets looked like that day are bored into memory. It was critical that we get the look of the area exactly right.”

The street-level view dissolves to an all-synthetic shot from a higher perspective, as the camera reveals most of *Manhattan*. “This second view was based on an image that Oliver had seen in one of the books about September 11, which was a shot of the smoke plume, as seen from satellite aerial photography.” After matching that image very carefully, Double Negative produced a final all-CG shot looking down on the earth from space, the smoke plume still visible.

After the collapse of the towers, rescue crews search — mostly in vain — for survivors within the smoking, burning debris field. To shoot post-collapse scenes, Jan Roelfs built an ingenious and immense exterior *Ground Zero* set on the Hughes airfield, referencing photography of the area shot in the days following September 11. “We also used lidar scanning of *Ground Zero* that was done under FEMA’s supervision in the weeks following the attacks. The purpose of these scans was to watch for shifts in the debris field, to determine if there were areas of instability. There were people working out there, and everyone was very fearful about more loss of life. Protecting the lives of the rescue workers was at the top of everyone’s minds, and these lidar scans helped officials to monitor the danger.”

The state-of-the-art scans were extremely high resolution. “The lidar data was so accurate, we could actually see where John McLoughlin’s Suburban had been abandoned on Church Street. To be able to see all the contours and shapes of *Ground Zero* was very helpful in re-creating the rescue site at Hughes.” To support the irregular set, which featured deep ravines and tall metal-beam peaks, Roelfs built atop large shipping containers, cutting out the fronts and backs to create tunnel access routes for the cast and crew. Roelfs’ crew also built a large retaining wall on the two sides of the set that faced the Pacific to ensure that ocean breezes would not disperse the practical smoke generated on set.

As vast as the *Ground Zero* set was, it represented only the specific area of the massive debris pile from which Jimeno and McLoughlin were extracted.

Double Negative extended the live-action set with its digital environments for a number of shots. An aerial view establishing the *Ground Zero* scene on the morning of September 12 combined a *Manhattan* helicopter plate — supervised by Double Negative’s Pete Bebb and directed by John Scheele — with digital elements. “Double Negative removed what was actually in the helicopter shot — the excavation and construction equipment that are currently at the site — and added CG smoke and debris. They also added heavy layers of dust to all the buildings in the photographic plate. On September 12, those buildings were still covered with dust from the pyroclastic cloud that spread out when the towers fell.”

In real life, the rescues of John McLoughlin and Will Jimeno were rare moments of triumph and joy in that bleak 24 hours. Their emotional impact is the same for filmgoers watching the climactic scenes in *World Trade Center*. “Even though this movie is intense,” John Scheele concluded, “it’s also cathartic to experience what happened that day through the eyes of those two police officers. Many people have commented that when they saw the real events unfolding, either in person or on television, they felt as if they were watching a movie. But in Oliver’s film, those same images feel like real life. The large screen and the sound and the power of cinema combine to create an experience that touches people’s hearts. It’s a positive and hopeful film — the film that needed to be made about September 11.”

World Trade Center photographs copyright © 2006 by Paramount Pictures.



Twenty-two hours after the towers’ collapse, rescue workers extract John McLoughlin from the rubble. Production shot live-action on a large *Ground Zero* set built on the airfield of the old Hughes Aircraft facility in Playa Vista. Production designer Jan Roelfs supported the irregular set by constructing it atop shipping containers, cutting out the backs and fronts to allow the cast and crew tunneled access to set areas. Double Negative enhanced the live-action by extending the set and adding in a 3D helicopter searchlight, foreground debris and smoke, and matte painted elements.

Overview

Mike Elizalde & Ed Hirsh on *Lady in the Water*

Article by Jody Duncan

No filmmaker since Alfred Hitchcock has made a more indelible mark as a teller of fantastic, often horrific and psychologically disturbing tales than writer/director M. Night Shyamalan. Following such distinctly suspenseful movies as *The Sixth Sense*, *Signs*, *Unbreakable* and *The Village* is *Lady in the Water*, a fanciful film reportedly born as a bedtime story the director imagined for his own children.

Set in the workaday surroundings of a modest apartment complex managed by Everyman Cleveland Heep (Paul Giamatti), the story concerns a mysterious, displaced bedtime-story character — the ‘Lady’ of the title, played by Bryce Dallas Howard — who is thwarted by evil, mythical creatures as she attempts to find her way home to her make-believe world. To populate his film with those creatures, Shyamalan turned to creature effects supervisor Mike Elizalde of *Spectral Motion* and visual effects supervisor Ed Hirsh of Industrial Light & Magic.



In the early stages of preproduction, Shyamalan worked with concept artist Mark ‘Crash’ McCreery to develop creature designs, including those for the prominently featured ‘scrunt,’ a large wolf-like character made of grass, roots and twigs. McCreery then approached a variety of effects studios, and finally — with Shyamalan’s approval — awarded the entire creature and makeup effects assignment to *Spectral Motion*. “We had several in-depth meetings with Crash at that point,” Mike Elizalde recalled. “He brought all of his drawings to our shop, and we looked at those carefully. I also read through the script. We were all very excited about the project, because the script was great.

“Of course, once we had the show, reality set in. Night didn’t want to use too much CG in the movie; and so he wanted this scrunt to be a practical creature that could walk and run, that could perform all kinds of head and facial movement. It had to look like a fully living creature in every way — but it also had to look as if it was made of grass! That was a really big challenge for us.”

Spectral Motion sculptor Moto Hata began by sculpting maquettes of the creature, based on McCreery’s drawings. “Crash had drawn several versions of the scrunt in different scenarios,” noted Elizalde. “There were pictures of it in a variety of storyboard moments, scenes from the script — standing in front of a washing machine, for example, his reflection in the door, or creeping around,

camouflaged in the grass. But we did have some creative freedom in designing the scrunt, because there wasn't one particular design that *Crash* had done that was the final, approved creature. *Crash* was very open to suggestions that would allow us to make this as a real, practical creature."



In M. Night Shyamalan's Lady in the Water, a displaced 'narf' attempts to return to her fictional Blue World with the help of residents of an apartment complex in whose swimming pool she is discovered. Throughout the film, the characters are stalked by 'scrunts,' wolf-like creatures made of grass, realized as puppets by Spectral Motion. Painting department supervisor Tim Gore Larsen details the scrunt maquette.

Spectral Motion sculpted three scrunt designs — one body maquette and three interchangeable heads — plus two full-size foam mockups, which Elizalde presented to Shyamalan in Philadelphia, where the film was shot, in three separate trips. “We presented *Night with the large* foam mockups to determine a sense of scale. One was bigger than the other, approximately the size of a tiger or a lion; but *Night* preferred the smaller one, which measured six or seven feet from the tip of the nose to the tip of the tail, and was about the size of a large wolf. *Night* wanted the scrunt to be big enough to look dangerous, but not so big that it didn’t fit into the world of the movie.”

With the design approved, *Spectral Motion* moved into construction of the scrunt, building a fiberglass understructure to house all of the mechanics, then covering it with a foam skin and custom-made, artificial grass. Going into the project, Elizalde and his crew had conducted extensive research and development, experimenting with different materials to create the grassy look. “We looked into plastic grass that you can buy at an art supply store. We looked at using real grass, and brought a few different types into the studio to examine. We went to a meeting with *Crash* in Philadelphia to talk to the greensmen about what kind of grass they’d be using for the show — because whatever we built for the scrunt would have to match the grass he was going to be hiding in. Once we had gathered all of that information, our fabricators got to work.”

Fabricator Fred Fraleigh hit upon the idea of using garbage bags for the grass, laminating several layers of the material together with contact adhesive, then cutting out individual blades. “Our lead mechanical engineer, Mark Setrakian, suggested using a laser-cutter to cut the blade shapes out of the laminated garbage bag material,” said Elizalde, “and that’s what we did. Then, each blade of grass had to be manually creased with a pizza cutter to create a spine-like indentation in the center. Finally, the blades had to be painted. Each blade of grass — about 30,000 of them per puppet — was hand-made that way, by a small crew. It was tedious work, but everyone had a great, upbeat attitude about it.” Once the *Spectral Motion* crew was on the set, Fraleigh acted as scrunt ‘hairstylist,’ adjusting the plastic grass blades prior to each take to ensure they looked good and were oriented properly to camera.



For walking and running scenes, Spectral Motion built a mechanical scrunt puppet that was mounted to a sled and dolly track and controlled through a computer interface system engineered by Mark Setrakian.

In total, *Spectral Motion* built five versions of the scrunt: a floppy dummy version, a non-articulated, lightweight stand-in, a rod-puppeteered version, a walking/running version, and a self-contained, battery-powered puppet that was staked to the set floor. All of the joints were actuated in the self-contained puppet, allowing for movement in the head, limbs and body that would make the creature look alive, even when it was merely standing in place. “That puppet could move from a lying down position to a full standing position. It could go from crouching to sitting. And since it was powered by batteries inside the body, there were no tethers or cables on that one. It was a real triumph.”

The performance of the self-contained scrunt and other puppets was controlled via a computer interface ‘black box’ engineered by Mark Setrakian, using new technology that was as yet untested in a film application. Setrakian had joined with engineering colleagues from other fields to create the computer interface system, drawing on the knowledge he had obtained while working at a government think tank. “Mark learned a lot and devised a lot of new engineering through that experience; and he was able to create a new hybrid technology for our little shop — which really gave us an edge. This was a unique application combining new and existing technologies.”

Although a few puppeteers were required to operate radio-controlled functions of the scrunt’s face and tail, the computer performance system enabled Setrakian, alone, to create all of the gross body moves — even complex walking and running cycles — sitting at the black box. “Mark was able to tell each servo specifically how to move in relation to all the others, and create profiles based on those instructions. He could also tweak it on the fly. It was a very complicated system, and very difficult to get up and running in the short amount of time we had; but it worked beautifully and simply once we were on the set.”

The system was especially useful in programming gait cycles for the walking/running scrunt puppet. Forward movement was achieved by mounting the animated puppet to a sled that traveled down a dolly track. “The sled had actuation, so the body would tilt and sway as it was running, just as a real animal would. We shot the scrunt running through a field of grass where we had set up the sled and dolly track, and it looked great. The grass was tall enough to hide the sled; so, all you saw was this animal running through the field. When we got it up and running, Night really seemed to enjoy what he was seeing.”

For the rod-puppet scrunt, mechanical department technician Eric Fiedler devised a system that enabled the creature effects crew to manipulate the puppet from overhead, with puppeteers beneath the stage operating limbs as others operated radio-control neck and head movement. “We



Industrial Light & Magic computer animated scrunts for shots too dynamic for on-set puppeteering. ILM scanned the fiberglass understructure of the Spectral Motion puppet to create the basic 3D form, then referenced photographs of the practical scrunt to model and texture an exact cosmetic match. ILM employed its fur program to simulate the character's verdant coat, adjusting characteristics to create individual 'hairs' that were flat and wide, like blades of grass.

used that puppet for a very effective scene in which you see the scrunt digging at the bottom of a door, trying to get in,” said Elizalde. “We hung it from overhead just to keep it kind of buoyant and alive. The overhead support also made it easier for us to manipulate the limbs from below.”

Though the scrunt was its most prominent creature, *Spectral Motion* contributed other creature effects to the film, as well, such as animatronic heads and suits for three ‘tartutics’ — fearsome simian-looking characters made of dead tree branches. “They look like gnarly old tree trunks that have come to life; but they also look like apes. They were really cool characters, beautifully designed by *Crash*, and created by Steve Wang and his team, including effects veteran Dave Grasso.”

Spectral Motion also created makeup effects for an apartment tenant named Reggie, portrayed by actor Freddy Rodríguez, who, out of boredom, conducts an experiment on himself, lifting weights and working out only one side of his body. “Because of this experiment, Reggie has one bulked-up arm and leg, while his other arm and leg are normal. We created a makeup for the right side of his body, which included a built-up leg, arm and chest to give him muscularity that was out of proportion to the rest of his body. It wound up being featured prominently in the movie, and it was a lot of fun. Freddy Rodríguez is a wonderful guy who was really willing to go the extra mile to make this work.”



In addition to scrunts, *Spectral Motion* built suits with animatronic heads for performers portraying ‘tartutics,’ fearsome law-enforcers from the *Blue World*, designed by production concept artist Crash McCreery to look as if they were composed of dead tree branches. Artist David Grasso sculpts a maquette for one of three tartutics produced for the show.

M Night Shyamalan's commitment to using practical effects for *Lady in the Water* is evidenced in Industrial Light & Magic's final count of just 100 visual effects shots — a remarkably low number, given the fantastic nature of many of the movie's characters. Among ILM's effects shots were those featuring a CG version of the scrunt, required for dynamic actions that could not be achieved with the practical puppets. "We started out with only three scrunt shots," Ed Hirsh said, "but we wound up with about 20 of them. I think that as things progressed, Night realized the potential of a CG character, in terms of expressiveness. My impression was that, originally, Night had thought of the scrunt as just this dark, ominous presence. But as he started seeing our animation, it opened up the possibility of the scrunt having more character."

Hirsh and his team — which included CG supervisor Kevin Barnhill, animation supervisor Tim Harrington and composite supervisor Marshall Krasser — studied photographs of the *Spectral Motion* hero puppet as they began to build their CG scrunt model. "Our job was simple in terms of defining the look of the scrunt," said Hirsh, "because that had already been done. All we had to do was make sure our scrunt matched the puppet exactly. We had reference photographs of it that we'd taken on location; and we also scanned the underlying sculpture of the puppet, without hair on it. That gave us the 3D geometry of the underlying structure; and then we added our CG blades of grass."

To create the grassy look, ILM artists started with the company's basic fur program, and then adjusted individual characteristics. "We made each specific 'hair' flatter and wider, changed the color of it, put a little curl at the end of it. All of that was based on careful study of the actual puppets and photographs. Our scrunt was rigged pretty much like the puppet, too. *Spectral Motion* gave us a blueprint of how their armature worked inside the puppet, so we knew where the joints were, how long each segment was; and then we matched all of that in our animation rigging."

In addition to referencing the behavior and motion of the live puppet, Harrington and his animators studied documentary footage of wolves and other animals as they developed the scrunt performance. "Night told us in one of our meetings that he thought real wolves or dogs looked too happy for the scrunt," Hirsh noted. "In the footage, they were always wagging their tails and generally moving in a way that made them look happy — and he didn't want that for the scrunt. So we also looked at hyenas, lions and tigers. Night liked how the hyena



Spectral Motion art supervisor Steve Wang, fabricator Jim Beinke and Tim Gore Larsen at work on the final stages of a tartutic suit. As with the scrunts, ILM created CG tartutics for scenes beyond the capability of human performers.



ran with its hips tucked under and low — he thought that was very creepy and scary. He also liked how hyenas lower their heads, so their shoulders are up over their heads somewhat. In the end, the scrunt's behavior was a combination of several different animals. And the performance changed, depending on the scene and the action and the environment the scrunt was in. For one scene where the scrunt was inside an apartment, Night wanted it to move like a scuttling bug, just to show a slightly different aspect of the character."

ILM created set extensions for the apartment complex that serves as the movie's sole setting. Initially, Shyamalan had intended to leave the area outside the apartment set's gated entrance empty, with only a few well-placed lights suggesting life beyond the complex. When the director determined that those lights were insufficient to create a sense of environment outside the gates, ILM photographed a Philadelphia neighborhood at night, and then tracked and composited those images into the entrance of the complex set.

While the scrunt performance required practical puppets and computer animation, the 'eatlon' — the large, mythical bird, similar to an eagle, that arrives to rescue the Lady near the film's end — was always a computer generated effect. "We started with *Crash*'s drawings of the eatlon," said Hirsh. "There was also a fully painted maquette that the *Spectral Motion* team had built, and we started with that as the basis for the eatlon geometry and textures. The eatlon's morphology is pretty much that of an eagle; but it is much bigger, and the coloring is much more exaggerated." Volumes of reference of real birds in flight formed the foundation of the eatlon animation. "We talked about all the different things the eatlon would have to do — flying and diving and soaring — and then Tim Harrington gathered all this reference of birds, showing what their wings did in all those situations. We showed the reference to Night so that we could really nail down what he wanted the eatlon to do."

Many of ILM's visual effects shots for *Lady in the Water* were environment-related, rather than creature-related. Though the entire film takes place within the apartment complex, called 'The Cove,' ILM was called upon to execute a number of 2D set extensions to suggest the neighborhood outside the complex gates. "The filmmakers found a location in Philadelphia that they liked for the neighborhood," explained Hirsh. "So they were just going to put a greenscreen up in the gateway entrance of the set, and comp in some plates shot in that neighborhood for a couple of daylight shots. Then, for all of the night work, they thought it would be black out there beyond the gate; and so they just placed a few lights out there, thinking that would suffice. But it was unsatisfying. It just didn't feel as if there was a real neighborhood out there. So we went to the location neighborhood and shot a lot of still photographs of it at night; and then we comped those stills into the plate photography, beyond the apartment complex gate."

Characterized by such subtle, straightforward effects, *Lady in the Water* was not a particularly big or difficult show for the digital artists at ILM. Rather, the film's major effects challenges were in the practical realm. "Working on *Lady in the Water*, creating a running creature, was one of the hardest things we've ever had to do," concluded Mike Elizalde, "especially in the amount of time we had. But it was a great opportunity to work with Shyamalan, whom I admire a lot. Most people who understand film admire him. On top of his technical filmmaking abilities, Night has a wonderful outlook, and his movies always have a great message. That's absent from a lot of filmmakers' projects these days."

Lady in the Water photographs copyright © 2006 by Warner Brothers.

Overview

Sterling Allen

A Scanner Darkly

Article by Estelle Shay

Richard Linklater, whose affinity for off-the-beaten-track, noncommercial filmmaking has made him a cult favorite, first ventured into animated fare in 2001 with *Waking Life*, an existential treatise calling into question our most basic assumptions about reality and dreams. Made for mere pocket change by today's standards, the all-animated film's artful, original look was the result of a novel technique, developed by *Waking Life* art director Bob Sabiston, that blended rotoscoping with digital technology. For his newest venture, *A Scanner Darkly*, which he adapted from a 1977 novel by science fiction writer Philip K. Dick, Linklater chose a similar animation approach to tell Dick's bleak tale of drug addiction and alienation in an oppressive, not-too-distant future world.

A Scanner Darkly follows undercover agent Bob Arctor (Keanu Reeves) as he dabbles in the super-psychedelic drug known as Substance D while simultaneously spying on his freeloading, drug-addled roommates Ernie Luckman (Woody Harrelson) and James Barris (Robert Downey Jr.), and girlfriend and supplier Donna Hawthorne (Winona Ryder). The lines between reality and hallucination blur as loyalties are questioned among the friends, and Arctor's covert duties even require him to conduct surveillance on himself.

Conceptually, Linklater's plan to animate the film was well-suited to the project. "These characters are living in this alternate, hallucinatory world, and it's a little weird," observed lead animator Sterling Allen, one of 30 artists originally hired to work on the film. "They're a little paranoid sometimes. They're under the influence of drugs, they're seeing things, and things just aren't quite right. The animation helps to put the viewer in that headspace."

Though the use of rotoscoping to make animation seem more lifelike is by no means new — Disney animators first experimented with it back in the 1930s, and it was used extensively by Ralph Bakshi in *Wizards* and his animated *Lord of the Rings*, as well as in the MTV music video *Take On Me* — Sabiston took it a step further. He wrote a software program called ColorEngine, the first of its kind to meld rotoscoping with a computer interface that allowed artists to scan video into a Macintosh and draw directly on top of it. The application also offered shortcuts to the painstaking process of



rotoscoping by making it possible to capture every nuance of a live-action performance without drawing every frame by hand. “Before Bob’s software, there was no way to interpolate — meaning you draw on frame one, skip three or four frames and draw on frame five, and the computer makes up what’s in between. So it would have been extremely time-consuming to do a whole film that way.”

As preproduction on *A Scanner Darkly* got underway in the spring of 2004, Linklater geared up for another collaboration with Sabiston, who spent much of the initial prep period on the picture conducting tests, writing new programs and further refining his software. He also began assembling a team of 30 local artists from Austin, Texas, Linklater's hometown and base of operations for the production. "For Scanner, they were looking for people who could draw. They wanted comic book artists or illustrators with tight linework skills, because there was going to be a lot of hand drawing." Many of those chosen had little or no actual animation experience — a qualification deemed unnecessary given the highly intuitive nature of Sabiston's software.

Under strict budget constraints imposed by the film's status as a Warner Brothers indie feature, Linklater conducted a whirlwind principal photography, shooting digital video of his all-star cast in Austin, and completing a live-action version of the film in just 23 days to serve as a blueprint for the animation. The movie was then edited, divided into 20-minute segments and imported into the computer as Quicktime clips. Sequences were further dissected into individual shots and assigned to animation leads, whose novice teams had to quickly adapt to a Wacom digital pen and graphics tablet in lieu of pencil and paper. "There was no two-week training period or month-long, dink-around, learn-the software period. When you finished a shot, it didn't matter if it was your very first closeup — it was going right into the film, not to be retouched until the movie was done."

The software interface was equipped with a timeline, a layering system, a color palette and a selection of tools. Animators would begin by using a keyboard shortcut to remove the color from a shot, making it easier to distinguish lines and shapes. Character animation often began with the tracing of a single line, carried through a shot. "If the character was talking, we might start with the upper lip line. We would draw that line on the first frame, then toggle forward in the video until it changed position, and draw it again. The computer would then fill in the missing frames, and interpolate the movement of the lip line from closed to open. Then we'd go back to the beginning and start with another line — say, the bottom of the mouth — and follow that one all the way through." Animators could toggle back and forth at any point in the shot to check their work, or preview it with sound. "If you didn't pay attention and back up frequently, the lip sync might be off or the head movement off; so, even though not every frame was hand-drawn, every frame was quality controlled. We were always stepping back through to make sure the animation was working." Once key lines were rotoscoped in this manner, animators could fill in with polygon shapes and color, using them to add highlights and shadowing that mimicked the lighting in the



Director Richard Linklater's 2D animated film *A Scanner Darkly*, adapted from a novel by Philip K. Dick, offers up a comical, but sobering, tale of drug abuse and alienation in a paranoid future world. To achieve the film's distinctive style of animation, Linklater relied on a computerized variant to traditional rotoscoping — a less sophisticated version of which was used in his earlier film *Waking Life* — allowing animators to closely mimic the live-action performances of an all-star cast that included Keanu Reeves as drug enforcement agent Bob Arctor and Winona Ryder as drug-dealing girlfriend Donna Hawthorne.

live-action video. Again, the computer software sped up the rotoscoping process by interpolating the movement of those shapes and filling in colors on in-between frames.

A beneficial by-product of the software's interpolation function was its ability to provide a more fluid look to the animation, removing some of its inherent jitter. "Bob probably worked on the software for more than ten years before *Waking Life* — which was made in 2001. So it had another four or five years under its belt before *Scanner*, and it's still going through changes. The version we were using had a very natural interpolation curve. It's not real robotic. So if you go from point A to point B, it's not going to be moving at the same frequency the whole way. It sort of ramps up, and moves in and out in terms of speed, with more of an organic curve to its interpolation."

Another significant improvement in the software was a function that further reduced jitter, particularly effective in facial animation.

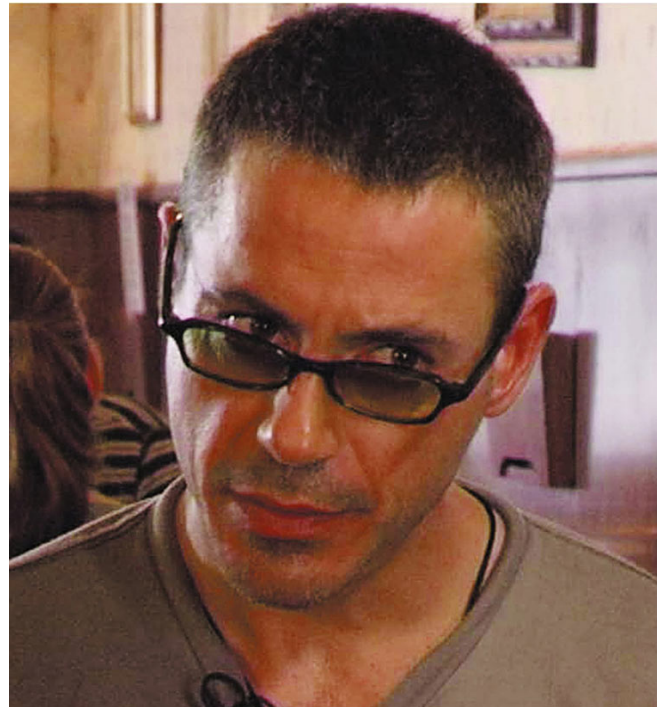
"Sometimes in *Waking Life*, one eye on a character's face would be moving at a different pace than the other, which in turn was moving at a different pace than the nose — so things got really jiggly. But with *Scanner*, we could step through to where we keyframed, to where the peaks of the movement were, and draw the other eyeline on the same keyframes so that the two eyes lined up and moved in sync. Same with the color, so it's not sliding all over the place and moving independently of the lines — which occurred in *Waking Life* at times. It was another way to speed things up, because you're not having to reinterpret the footage every time. You interpret it once, on the first line, you get the movement exactly how you want it; and once you've established that — maybe it's 30 out of 60 total frames that you've keyframed — you just step to those 30 keyframes, and now your scene is cut in half."



In an early sequence, Arctor, wearing a 'scramble suit' to protect his identity as an undercover agent, prepares to address members of a civic organization as part of his agency's ongoing campaign to educate the public on the dangers of the psychedelic drug, Substance D. For scenes of his character's wearing the scramble suit disguise, Reeves wore a generic jumpsuit during live-action filming, which animators subsequently translated into a complex kaleidoscopic effect comprised of layers of random and continually shifting facial features and body parts, blinking on and off in rapid succession and contained within a diaphanous membrane.

One aspect of the software that animators found particularly helpful was its ability to freeze layers of a drawing and slide them around if needed, much like cardboard cutouts. Backgrounds were separated out and 'frozen,' as were other objects that did not need to be redrawn from frame to frame. "If you have a car moving down the highway — a solid form that isn't changing, but just needs to move — you wouldn't want to have to draw it over and over. So we'd draw it once, freeze that layer and then use the hand tool to reposition it in each frame." The tool also enabled animators to scale objects or backgrounds as needed, and to create a sense of parallax in the 2D environments for shots in which the camera was moving. "We had to build our environments out of completely flat planes, since the software is vector-based and completely 2D, but we could shift those planes on an x- and y-axis, like tilting a playing card. So if we were drawing the interior of a house, for example, each of the four walls could be illustrated just once, then shifted around and tilted in any direction to get the desired view."

Though Linklater shot much of his live-action with a Steadicam, animators found it necessary to add a bit of minor camera shake to many backgrounds in order to sync them with the foreground action. “With backgrounds, you’re kind of idealizing the movement; but with characters, you don’t have that option. You have to go exactly from what’s there on the video. You’re trying to capture every little tic and shake and nuance of the actor’s performance. So making those two worlds live together was challenging. When we were rotoscoping characters frame by frame and grafting their movement perfectly to the video, there would be these slight camera fluctuations; and if the background didn’t have those fluctuations, it would look like the character was swimming.”

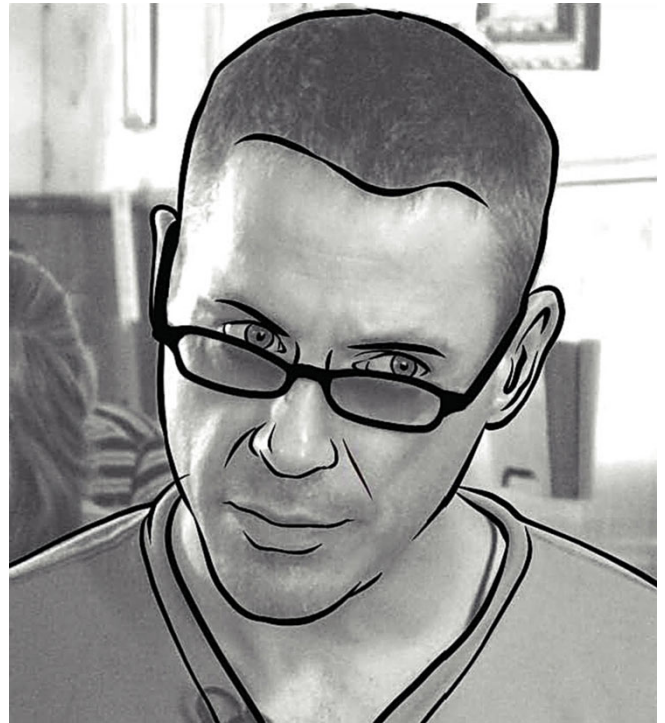


Robert Downey Jr. played Arctor’s duplicitous roommate, James Barris, during the 23-day digital video shoot. Animators worked from a cut of the live-action video, which was imported into Macintosh computers as Quicktime files. Using vector-based 2D software developed by Bob Sabiston, artists worked frame by frame, first removing all of the color from a shot, then hand-tracing over the black-and-white video image with simple bold lines drawn at keyframe intervals to track key character movements, such as lip-sync. Software tools provided shortcuts to the labor-intensive process by interpolating the movement on in-between frames.

Unlike *Waking Life*, where artists were given free rein to express themselves, and animation styles within the film fluctuated wildly, Linklater sought a more controlled look and style for *Scanner* — an issue of contention that reportedly contributed to Sabiston's premature departure from the show just four months into production. "Bob is a huge fan of letting an artist have some footage and put his personal spin on it. In *Waking Life*, the main character, Wyle Wiggins, is drawn in so many different styles throughout the film that he sometimes isn't even recognizable. But I think Bob really likes that kind of fluctuation."

Following the departure of Sabiston and several of his lead animators, the film's producers appointed new leads, added another twenty animators to the crew, pushed for tighter deadlines and insisted on guidelines to ensure a more consistent look to the character animation. "We developed a physical style guide that included some rules for drawing the characters. Winona, for instance, was mostly drawn with brown lines instead of black ones because black lines looked a little harsh, and we wanted her character to be softer. Woody was usually drawn with no bottom lip line because it fit his character better not to have it; whereas for someone like Robert, with big full lips, we would use a black lip line, and Keanu the same. What worked best, though, was just paying attention to what was happening each day, and getting input from Rick. He would say: 'I don't like the way Winona looks in that shot,' or 'I don't like Keanu's beard in that shot, but I do in this one' — so that became our reference. We also got feedback from preview screenings once the movie was finished. It was a furious pace to finish the movie and not fall behind, so we didn't have time to get up and run around as much as we would have liked. But from October 2005 through February 2006, we did nothing but tweak shots — especially some of those early ones where we were still learning. That last four or five months, the style just sort of came together organically."

Though the rotoscoping process allowed animators to closely adhere to the actors' performances in the film, it also freed them to add some imaginative flourishes of their own for scenes involving a series of Kafka-esque hallucinations, and for a 'scramble suit' that Arctor and his undercover superiors don to disguise their real identities. The bizarre suit rendered its wearer anonymous by masking his real features with a projection of swiftly-changing alternate physical attributes that metamorphose at such a rapid rate, no one face or feature is recognizable, and there is no sense of an integrated whole.

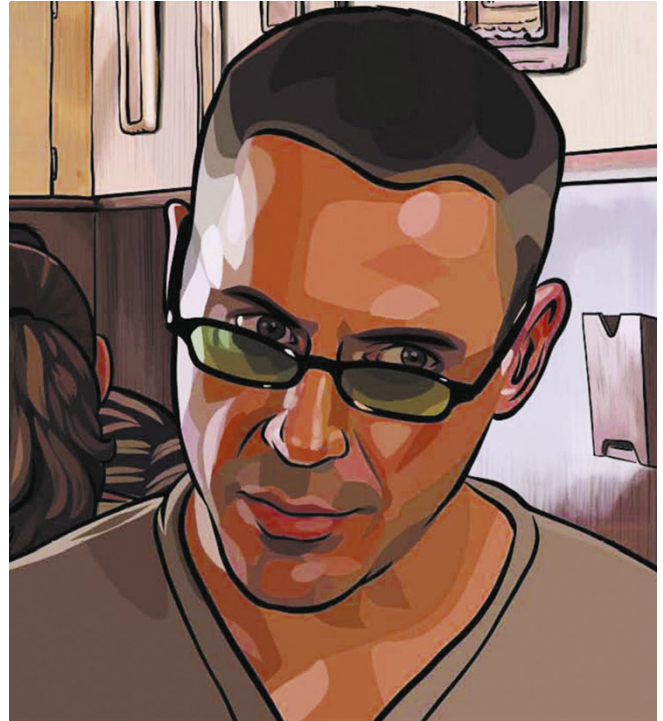


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Sabiston and animation lead Patrick Thornton had spent months experimenting with the design of the scramble suit before arriving at a version that met with Linklater's approval. "Some of those early scramble suit tests got really crazy. One was almost nauseating to watch, because it looked like neon bees buzzing all over someone. Another had little panels of motion flying all around, and there were others where you could not even make out a feature; it just looked like a blur of color because it was moving so rapidly and the chunks were so small. Rick liked the idea of a membrane that sort of kept everything together, and he liked the idea of never being able to really see one face completely."

Lead animator Nick Derington, along with assistant scramble suit lead Ryan Parker, continued the work in the wake of Sabiston's departure from the show, subsequently overseeing all of the scramble suit shots. Shots involving Reeves were particularly challenging in that the animators had to maintain Reeves' performance — capturing the emotional essence, the lip sync, the movement — but hide the actor within. The process was further complicated by the sheer number of different looks that had to go into every scramble suit shot to achieve the desired effect of a virtual kaleidoscope of changing body parts and features. To that end, every shot was assigned to three animators, each tasked with producing a separate thread of animation. Every face they created was divided in half, a different look assigned to either side, and flipped into something entirely new every thirty seconds. With thousands upon thousands of variations required for every scramble suit sequence, animators were hard-pressed to find distinct faces for all their shots. "You can imagine constantly having to dig into your well of characters every single day for eight hours a day. For a while, all of the Incredible family were in there, and Yosemite Sam and Sponge Bob. After a while, everybody was in there — brothers, cousins, even Philip K. Dick."

Each animation thread was assigned an opacity frequency to stagger the rate of change, and the various layers — including one designed to mask bits and pieces of the thread as it was revealed — were combined. "Altogether, there were maybe five layers, and then the membrane had to be drawn and masked to keep everything inside that shell; so that was another whole process. The overall effect is that you never get a steady, pulsating, rhythmic sort of fluctuation. It's a really varied look. You can't put your finger on the pattern because it's constantly moving."



Once the animation was complete, color was introduced into each shot, together with shifting highlights and shadows in the form of animated polygons, with the computer again interpolating shapes and colors between keyframes. In addition to the interpolation function, which noticeably reduced the amount of jitter inherent in the technique, other useful and time-saving features of the software included the ability to freeze layers of a drawing, and position and scale them, eliminating the need to draw objects and backgrounds repeatedly in shots where camera movement created shifting parallax views.

Postproduction on *A Scanner Darkly* wrapped in February 2006, overdue and overbudget, despite the fact that throughout fifteen months of postproduction, Allen and his fellow animators had worked at a furious pace to complete the film. Ultimately their efforts won a reprieve from the Warner Brothers producers, who at one point had threatened to shut the project down if increased quotas were not met. “No one really anticipated the amount of detail we were going to be able to get from this process of animation, or how far we were going to be able to take it this time. But once the look was established, I think the producers and the studio realized that rather than tone us down and dumb down our animation in order to finish in nine months instead of fifteen, it was worth it to fight for that extra time and make the movie Rick intended.”

A Scanner Darkly photographs copyright © 2006 by Warner Brothers.

One for All Time

image

ARTICLE BY JODY DUNCAN

In the history of photography, no image has been more universally recognized, more celebrated or more frequently reproduced than that of six young soldiers raising the American flag atop Iwo Jima's Mount Suribachi in the midst of a terrible *World War II* battle in the South Pacific. That photograph — dubbed 'one for all time' by an Associated Press photo editor — became a symbol of hope so powerful, so inspiring, it played a significant role in turning the tide of war for America and her Allies.

And yet, for decades, only *World War II* history buffs knew anything of the events surrounding that flag-raising. Fewer still knew anything about the flag-raisers themselves — their names, their histories, their fates, their post-war lives. James Bradley, the son of one of those six, set out to uncover the truth behind the image — a truth his reticent father never spoke of — shortly after the elder Bradley's death in 1994. The fruit of his research, which included interviews with veterans of the bloody battle at Iwo Jima, was *Flags of Our Fathers*, a 2000 bestseller written by Bradley with Ron Powers.

Among the millions of readers who found themselves moved by the book's alternately horrifying and poignant story was director Clint Eastwood, who was on the lookout for a project to follow his Malpaso Productions' *Million Dollar Baby*, the film that had won Eastwood his second 'best director' Academy Award. After deciding to take on *Flags of Our Fathers*, Eastwood called visual effects supervisor Michael Owens — with whom he had worked on his 2000 film, *Space Cowboys* — asking that he read the book and give him some ideas as to the number and types of effects that might be required to translate the story to film.

Meanwhile, screenwriters adapted the book, crafting a nonlinear storyline that jumped from place to place and from time period to time period. As scripted, the film would be an ambitious undertaking, requiring the shooting of chaotic, high-energy battle sequences — rivaling the opening 20 minutes of Steven Spielberg's *Saving Private Ryan* — as well as modern-day sequences and those following the three surviving flag-raisers as they tour 1940s' America, selling war bonds.

Even more ambitious was Eastwood's plan to immediately follow the filming of *Flags of Our Fathers*, which told the story of Iwo Jima from the American perspective, with the shoot for a film tentatively titled *Letters From Iwo Jima*. Scripted by Iris Yamashita, *Letters From Iwo Jima* would depict the battle as seen through the eyes of the Japanese soldiers, and would be released shortly after the first film. The atypical production schedule meant that the 500-shot visual effects assignment for *Flags of Our Fathers* — which Owens, as production visual effects supervisor, awarded to Digital Domain — would segue, without break, into effects production for *Letters From Iwo Jima*.

Once DreamWorks and Warner Brothers had given the two-part project a definite 'go' — with Steven Spielberg serving as producer, along with Eastwood and Robert Lorenz — the filmmakers began scouting locations. Top priority was finding a location that could pass as Iwo Jima for the

filming of the movie's battle sequences. A location no more exotic — or authentic — than Catalina Island, off the Southern California coast, had stood in for the island in the 1949 John Wayne film, *Sands of Iwo Jima*. Eastwood and his production crew were looking for a site that was grittier and more genuinely representative of the real South Pacific battleground. "There was a very specific kind of black sand on Iwo Jima," Michael Owens explained, "and that was an important story point. So, among other things, we had to find a place that had that same kind of distinctive black sand."

The pursuit of authenticity led Eastwood to scout Iwo Jima itself — although he knew, going in, that the uninhabited island, a place considered sacred ground in Japan due to the thousands of its soldiers buried there, was not going to be the most hospitable shooting location. While Eastwood and his team did gain permission to shoot some footage on Iwo Jima — resulting in a final modern-day shot of the island memorial for *Flags of Our Fathers* and many more shots for *Letters From Iwo Jima* — the production needed a more suitable location for the majority of the film's combat sequences, which would involve heavy pyrotechnics, hundreds of performers and crewmembers stomping through the terrain, and a lot of ships, tanks and other hardware. "We scouted areas of Hawaii and California," said Owens, "because we knew we could make any color of sand black in post, if we had to. But we thought it would be great if we could shoot someplace where the sand was really black. I mentioned that I had seen some plate work that had been shot in Iceland, and I recalled that it had the same sort of volcanic, black look that Iwo Jima has. So Rob Lorenz and his location scout checked it out, and then went over there and brought back some stills."

Despite the fact that Iceland and Iwo Jima are separated by nearly 6,000 miles and enjoy very different climates — the former cool and temperate, the latter, tropical — those stills clearly illustrated that their landscapes were remarkably similar. "Iceland is not the most obvious choice to shoot a South Pacific war movie," Clint Eastwood allowed. "But then, when you analyze it, it makes sense. They are both geothermal islands. Both have black sand beaches. So, although we looked at one another strangely when we were first approached about shooting in Iceland, once we got there, we could see it was a good match. Iceland made a great location."

"It was amazing to see how well the terrain in Iceland matched the terrain in the historical footage of Iwo Jima," Owens elaborated. "In fact, the areas we scouted in Iceland matched the historical footage much better than present-day Iwo Jima did, because Iwo Jima now has a lot of foliage on it. At the time of the battle, the island had been bombed for several days prior, so there was no foliage left. The terrain was barren, and that's how these locations in Iceland looked. We wound up shooting almost all of the battle stuff in Iceland, at four different locations, including a beach and an inland mountain that stood in for Mount Suribachi."

In addition to scouting, Owens spent the preproduction period producing artwork that served to define visual effects shots, while also aiding Eastwood in developing the film's overall visual style. The artwork included Photoshop images, as well as key scenes from the script rendered by a storyboard artist. "I threw together these concept illustrations," stated Owens, "and then presented



With Flags of Our Fathers, director Clint Eastwood and his Malpaso Productions translated to screen James Bradley's

them to Clint, very early on, and asked him if this was the direction he wanted to go. Clint's take on it, and mine, was that the shots should be very photoreal. *Saving Private Ryan* was really the benchmark. This movie, like the opening of that one, needed to be intimate and subjective. We did not want to see platform establishing shots. We wanted every shot to be motivated from a character's point of view. Even if it was really an objective shot, we wanted it to feel as if it was a subjective shot."

More than these concept illustrations and storyboards, historical stills and documentary footage from the Iwo Jima conflict, gathered by production, significantly influenced the visual style of the film. "We very carefully studied every bit of documentary footage and all the stills that we could find in books and other sources," said Owens. Among the moving footage reviewed by the filmmakers was that shot by Sergeant Bill Genaust, a Marine combat cinematographer who died on Iwo Jima shortly after the flag-raising. "There wasn't a lot of moving footage such as that shot by Genaust; but there were a lot of stills — stills shot by combat photographer Joe Rosenthal, who took the famous flag-raising photograph, and other photographers. Those photographs, though, were typical of the era in that they weren't really taken in the heat of battle. Generally, the combat photographers would stay back while the front lines went through and fought; and then, later, after an area had been secured, the photographers would come in to shoot. So most of the photographs were taken just after the real fighting. Still, they gave us an idea of what everything looked like there, and we got some very iconic images from those photographs and from the documentary footage."

Though Eastwood and his production heads studied the historical reference closely, it was never their intention to re-create specific stills — with the exception of the Rosenthal photograph — or to stage exact reenactments of sequences from the documentary footage. Even so, the battle shots, as they evolved into their final form, would be eerily reminiscent of the images captured by the real combat photographers and filmmakers on Iwo Jima. "We never looked at the iconic images in those photographs and in the moving footage, and said, 'Okay, we're going to create this specific shot,'" said Owens. "We just emotionally digested all of these images, and went out and shot the movie. But, strangely enough, when it was all done, the shots from the movie looked just like the documentary and still shots from the real Iwo Jima. It was uncanny. The feel of those shots was exactly the same."

nonfiction bestseller about the six Marines who raised the American flag atop a summit on Iwo Jima, an event that was immortalized in the most famous photograph of the World War II era. Production visual effects supervisor Michael Owens and the artists at Digital Domain incorporated computer generated environments, military hardware, explosions, smoke, fire and other atmospherics into live-action plates to enhance the film's gritty combat action.



Shots leading up to the invasion of Iwo Jima — a small island in the South Pacific that served as a strategic Japanese stronghold — included expansive views of a Navy convoy of 800 ships that extended for 70 miles. Production shot ocean plates from the S.S. Lane Victory, an authentic World War II vessel, to which Digital Domain added ten varieties of computer generated destroyers, battleships, cruisers and troop transports. For convoy closeups, and for later scenes off Iwo Jima's shore, modelers built and textured some of the ships to a very high level of detail.

“You can really see it when you look at the end credits,” added Eastwood. “We used photographs from the real battle in the end credits, and you can see that those shots are very similar to the ones that are in the picture.”

With the aesthetic approach determined, Owens broke down *Flags of Our Fathers*’ effects shots into three distinct categories: effects that would fill out and enhance *wo Jima* battle sequences, those that would create period locations for the war bond tour scenes, and cleanup and fix-it shots for the modern-day sequences. The *wo Jima* sequences were also subdivided into pre-battle shots — views of the vast Navy fleet en route to *wo Jima*, as well as the ships’ approach to the island and the subsequent beach landing — the initial battle on the beach, the climb up Suribachi and the flag-raising, and shots from atop the captured mountain, in which skirmishes on the other side of the island would be on view.

For the live-action battle scenes filmed during the production’s seven-week stint in Iceland, Eastwood’s strategy — developed in preproduction with Owens, director of photography Tom Stern and production designer Henry Bumstead — was to shoot foreground and midground material only. “Our plan all along,” noted Owens, “was to shoot just what we absolutely needed for the foregrounds and midgrounds, and then fill in everything else with visual effects.” Owens assigned Digital Domain, under the leadership of visual effects supervisor Matthew Butler, the task of filling empty backgrounds with photorealistic environments, ships, vehicles and other hardware, atmospherics, explosions, weapons fire and troops.

Even with this reliance on visual effects, however, the live-action setups for the battle sequences in *Flags of Our Fathers* were very large in scale. “It wasn’t like we had three guys there and we added everything else,” Eastwood explained. “We had eight to nine hundred people on those beachheads, plus crew. It was logistically complicated.”

Eastwood captured the frenetic combat action with a freely moving, often handheld camera, a documentary-style approach made possible, in part, by the decision to shoot very little bluescreen material on location. “We stipulated from the beginning that we wouldn’t do much bluescreen,” Owens explained. “To keep the shots photoreal, we couldn’t be shooting against monstrous bluescreens out in the elements, with wind and rain and everything else. Environmentally, that location was never going to be conducive to shooting bluescreen.”

Another consideration in keeping bluescreen to a minimum was Eastwood’s famously fast-paced shooting style. “It’s very hard to keep the rhythm of shooting a show if you’re busy setting up bluescreens all the time,” Eastwood commented. “The tail can start wagging the dog sometimes when you get into that stuff. Pretty soon, everybody is setting up the visual effects, and you forget



*In addition to the Lane Victory, production shot the U.S.S. Texas – a veteran of both World Wars – at a site near Houston where it is on display. Digital Domain surrounded the moored battleship with CG water and skies, and then, for scenes of its shelling *wo Jima* in advance of the land assault, replaced its inoperable gun turrets with rotating and recoiling CG versions and added belching fire and smoke. Digital Domain also augmented and customized its proprietary water simulation software to create concussive depressions in the water produced by the force of the big guns’ discharges.*

that there are actors and crewmembers and a lot of other departments that need momentum to keep them rolling on through. So the visual effects people just had to kind of swing with us a bit — and they were terrific at doing that. We all whipped right along.”

Though of great benefit to the on-set crew, the no-bluescreen mandate resulted in a major rotoscoping job for Digital Domain. “I told the people at Digital Domain that this was not sloppiness on the set,” Mike Owens recalled, “that it was intentional. The no-bluescreen decision was a critical part of the design of the show. By shooting it this way, it wouldn’t look like a visual effects film. The lighting would be natural, and the camera would be completely unlimited. Clint was able to shoot most of his shots handheld or with Steadicam — and you would never have done that shooting bluescreen.” Fortunately, there were specific characteristics of the film that made the decision to rotoscope, rather than shoot against bluescreen, a very well-calculated risk. “It helped that the soldiers were wearing helmets and stiff uniforms, which meant that there wasn’t a lot of long blonde hair blowing around. All the soldiers had short-cropped hair, even when their helmets were off. Because of that, I knew that roto was the right way to go, and that it wasn’t really a risk at all. If there had been any chance that it would have compromised the shots or made them look artificial, we wouldn’t have done it. But in this case, it was a great calculation, and the right thing to do.”

Even so, the rotoscoping assignment for *Flags of Our Fathers* was a huge undertaking, requiring months of intensive labor during postproduction. “It was the biggest rotoscoping job I’ve ever been involved with,” stated Digital Domain digital effects supervisor Bryan Grill. “Sixty-five percent of the shots we worked on for this show had major roto on them. The highest number of rotoscoping artists we’ve ever had for past shows was ten. For this show, we were up to 20 artists. It was a huge, huge job.”

Large-scale practical effects executed on location by special effects supervisor Steve Riley and his crew to simulate weapons fire and shelling complicated the rotoscoping effort. Though these practical effects had grounded scenes in reality, created on-set excitement, and provided the actors with real events with which to interact, they also made for shots that required the most meticulous and painstaking rotoscoping imaginable, as artists attempted to position their CG elements behind and in front of practical flak, explosions, dust, sand plumes, fire, smoke and debris.

“Originally,” explained Grill, “the plan was that they’d shoot three takes for each shot — one with no explosions going on, one with only minimal pyro, and one where they’d go for the full blast. The idea was that we would then be able to pick and choose from those takes when doing the final shots. But that just didn’t work with Clint, because he shoots so fast. Sometimes, he’d like the rehearsal just fine, and he would say, ‘That’s the one,’ and move on! We’d never had to deal with



When the shelling ceases, troops and landing craft head for Iwo Jima's shore. Production used approximately 25 period watercraft – including foreground 'LVTs' -- for the sequence, which Digital Domain augmented greatly with computer modeled ships. Among the real ships employed on location was a modern Coast Guard vessel, which created an appropriate-sized wake in the water and also provided deck and railing elements for the accurate placement of on-board troops created through Massive. In postproduction, Digital Domain retained the wake and troops, but replaced the anachronistic craft with a period CG ship.

that before; and so it was a learning experience. But we knew we had the people and the technology to handle whatever we got as a result of that shooting style. Our theory was, whatever we couldn't get behind, we would just replace. So, if there was an explosion and we couldn't roto it, we'd chop it out, and then put a brand new one on top of it. We did the same thing with smoke and other atmospherics. Compositing supervisor Darren Poe and his team integrated tons of practical and CG elements into those shots. A shot with live explosions, no matter how big, would be twice as big and have twice the number of explosions by the time we were done with it. No matter how much they did on the set, it was only a fraction of what wound up in the final movie."

As production delivered live-action plates to Digital Domain, the effects artists began mocking up shots, filling empty areas of the frames with crude digital images. These mockups not only served as guides for Digital Domain as it realized final effects shots, they also helped Eastwood and editor Joel Cox in assembling a rough cut of the film. "At that point," related Owens, "there was a lot missing from some of these shots, because they still needed visual effects. So we mocked up shots, largely for storytelling purposes. Those mockups allowed Clint and Joel to see what would be in the backgrounds of their live-action shots, and to play with each scene, which really helped the editing process. I would present the mockup shots to Clint, and then Joel would re-edit the sequence, using those shots. Clint would give us comments, and we'd modify our mockups at that point. From there, we moved on to final, refined shots."

Though the majority of Digital Domain's shots would involve completing and enhancing these live-action plates, some were designated, from the beginning, as entirely synthetic shots. Among the all-virtual shots was a wide aerial view of the awesome Navy fleet converging in the South Pacific, on its way to Iwo Jima. Historically, the 800-ship armada included a 70-mile-long convoy of transport ships, destroyers and battle-ships that departed *Pearl Harbor* in January 1945 and then merged at sea with another fleet out of Australia. "Even though, factually and historically, there were 800 ships, we may have had more than that by the time we were done with this shot," noted Matthew Butler. Lead CG modeler Melanie Okamura and her team modeled troop-carrying ships, cruisers, destroyers, battleships — about ten different ships, all together — some of which had to be finished to a very high level of detail to accommodate subsequent closeups. "They modeled and textured these ten different types of ships, and then we mixed and matched them to make it look as if there were many more varieties."

The all-virtual shot, in addition to CG ships, sky and ocean, featured 3D troops aboard the vessels, created through Massive. *Flags of Our Fathers* represented Digital Domain's first large-scale use of the state-of-the-art crowd generation tool. "We've never actually used Massive on a full feature before," Butler stated. "We've used it in commercials, little pieces here and there; but Massive only really pays off if you need a lot of characters in a large number of shots, because you expend so much energy up front, just setting it all up. In this case, we had many, many shots, with hundreds of soldiers running around; so *Flags of Our Fathers* was a perfect project for employing Massive. It was a really beneficial tool for us on this show."

The preliminary Massive work included motion capture sessions at Giant Studios — one weeklong session early on, and an additional few days later in the postproduction schedule. "We worked with choreographer Michelle Ladd, who has done this before, specifically for Massive," said Butler. "So

there was that work, just acquiring the data. The more significant up-front work, though, was building the brains that drove the behavior of the soldiers. The way Massive works, you're not keyframing or specifically animating certain soldiers — you just couldn't do that for hundreds and thousands of characters. Instead, you create behaviors for characters, and just let them do what they would do. The brains say, 'Given this situation, this character will tend to do this.' It uses logic, so it's quite natural. But you have to educate your agents for them to behave appropriately. And you need sufficient complexity in the brain to result in behaviors that are complicated enough to look natural. So a lot of work went into that, but it really paid off for us. The Massive stuff looks fantastic. Not only do we have Massive for wide shots with a lot of soldiers — such as the all-CG shot of troops aboard the ships at sea — in one case, we used it to create a shot of only five or six soldiers, fairly close, marching away from camera with their guns. That would have been an easy thing to shoot, of course; but Clint moves fast on the set, and this was something that came up after the fact. So we just created Massive soldiers, even for that relatively close shot."

The photorealism of the armada virtual shot was crucial, as it cut back-to-back with live-action footage of the S.S. Lane Victory, a real *World War II*-era ship, commissioned by production, that was taken out of dock in San Pedro and filmed off the coast of Southern California. The Lane Victory stood in for the U.S.S. Missoula, the actual ship that transported troops — including flag-raisers John 'Doc' Bradley (Ryan Phillippe), Rene Gagnon (Jesse Bradford), Ira Hayes (Adam Beach), Mike Strank (Barry Pepper), Harlon Block (Ben Walker) and Franklin Sousley (Joseph Cross) — to Iwo Jima.

"We took the Lane Victory out to sea toward Catalina," stated Butler, "and we shot it on the water for about a week — both closeup stuff on the ship and wide shots of the ship at sea, which we shot during our one aerial day. As it turned out, we didn't get very much value out of having the ship out there on the water for the long shots, other than for reference; but, we decided to keep it in those shots anyway, rather than replace it entirely. There were little anachronistic things on the ship, things they'd added to it through the years; but, fortunately, it was so small in frame in these long shots, those elements didn't matter. So we kept that ship in the shots, then surrounded it with a lot of our CG ships to fill in the rest of the fleet."



Troops disembark from landing craft to seize the beach at Iwo Jima. For the sake of authenticity, production sought filming sites that would match the real island's rocky volcanic terrain and black-sand beaches. Various coastal and inland locations in Iceland — where production shot for seven weeks — proved near- perfect doubles for Iwo Jima's distinctive landscape. In wider shots revealing the entire length of the landing beach, Digital Domain extended the shorter Iceland shoreline digitally to replicate Iwo Jima's three-mile-long stretch of black sand.

Historically, the American battle plan called for the Navy force, upon its arrival at Iwo Jima, to shell the island for ten days prior to troops disembarking, as a means of ‘softening up’ the Japanese stronghold there. However, higher-ups in the chain of command, for a variety of political and strategic reasons, reduced the number to three days of shelling — which was further reduced to only a day and a half when overcast weather conditions precluded accurate targeting.

Though the shelling period at Iwo Jima had been truncated, there was ample real-life reference of offshore battleships and destroyers firing their massive guns toward land. That reference proved invaluable to the crews at Digital Domain as they created their shots, adding CG ships to offshore footage shot in Iceland, in some cases, or generating everything — the ocean, ships, shelling and island — in CG. “Most of the reference was in black-and-white,” said Butler, “but it showed us exactly what happened in all these different combat situations. It told us the behaviors and scales and dynamics involved. We could see in the reference that when these big battleships fired their guns, the guns were so huge their firing created a massive concussive shockwave in the water around the ship. Way back in the beginning of the project, someone had presented me with a reference image that clearly showed this gigantic concussive depression in the water. CG supervisor Jonah Hall and his team re-created that look by augmenting and customizing our water simulation. Realistically portraying that kind of shockwave in water is something I’ve never seen in a movie before.”

Subsequent ‘D-Day’ combat sequences begin with shots of troops disembarking from transport ships and smaller watercraft to storm the beach at Iwo Jima. Production had photographed most of the D-Day live-action on the beach in Iceland, which the art department had altered cosmetically, building up a berm of black sand that was clearly visible in the historical documentary footage. “The Iceland beach,” Michael Owens noted, “had sand that just sloped gracefully down to the water. So the production built this 300-yard berm; and then, in post, Digital Domain added to each end of that. They also extended the entire Iceland beach, which was only three-quarters-of-a-mile long, to make it look like the three-mile-long beach at Iwo Jima.”

To accommodate parallax issues created by the constantly moving camera, Digital Domain built the beach extensions in 3D, often employing its proprietary procedural terra-forming software, EnGen, which generated environments using topographical data from Iwo Jima. Digital Domain artists then tweaked those landscapes with additional modeling or matte painting, using photographic or painted elements as their reference.

In addition to extending the beach through EnGen, Digital Domain used the procedural tool to produce wide views of Iwo Jima, as seen from the ground, from atop Suribachi, and from the air. “Our team did a great job of creating Iwo Jima using EnGen,” commented Matthew Butler. “In



To fill out a live-action plate of Marines disembarking from real Higgins boats on the Iceland beach, Digital Domain added a CG version of the landing craft, filled with Massive troops, to the foreground. Digital Domain also employed its terrain generating software, EnGen, to situate the iconic Mount Suribachi – the site of the American flag-raising – into the background, massaging the procedural results with matte-painted elements. All Iwo Jima EnGen environments were based on actual topographical data from the island.

general, whenever you see wo Jima terrain, that was created through EnGen — and quite successfully.”

Among the EnGen-created wide views of the island are those seen from the summit of Mount Suribachi. “You see all over the island from the top of Suribachi,” explained Bryan Grill, “not just the beach area, but the inland parts of the island, as well. You see landing strips at the other end of the island, where other troops are fighting; you see skirmishes going on all over that end of the island. And then, on the beach side, you see them carrying injured soldiers and dead bodies, loading them onto ships. That whole wide shot from the top of Suribachi is synthetic.”

The entire island is also revealed in all-CG shots designed from the point of view of Corsairs flying overhead. “You see EnGen terrain down below,” Grill observed, “as well as CG boats landing on the beach, people on the beach, smoke, explosions, flak — all synthetic. As with all of our shots, Michael Owens wanted these aerial views of wo Jima to be subjective, rather than platform establishing shots. So we designed them as if they were being shot from the cockpit of one of the planes.”

To ground the D-Day live-action in reality, production had acquired and shot some real *World War II*-era ships and hardware on the beach and offshore in Iceland. Vessels included eight Higgins boats — the nearly forty-foot-long landing craft vehicles — as well as eight ‘LVTs,’ the amphibious, tracked landing vehicles. Production also filmed some real cannon-firing tanks moving up the black-sand beach. “We probably had 25 vehicles out there all together,” recalled Michael Owens. “We also borrowed two ships from the Iceland Coast Guard for long-distance shots of ships approaching the beach. They were far enough away that it didn’t matter that they weren’t true period ships. Even though we had to augment these shots quite a bit in post, it was good to have some of those real vessels and vehicles there on the beach for lighting and texture reference.”

Re-creating history, Digital Domain added another 200 watercraft and vehicles to the D-Day beach landing shots. “In every shot,” remarked Bryan Grill, “when you’re looking out into the ocean or along the beach, you see hundreds of ships and vehicles and hardware. There were twelve waves of landing craft that came ashore that first day; and so, we couldn’t get away with just showing a few boats here and there — which is what they did, very cleverly, in *Saving Private Ryan*. As fantastic as that movie’s opening scene was, they actually had only a few boats that they shot; beyond them, all you see is clear ocean. In this, that ocean and beach had to be filled with boats and landing craft to get a sense of the scale of this assault.”

The large numbers of craft helped to illustrate an important story point, which was the offshore ‘traffic jam’ that occurred as the numerous boats and troops expelled from the larger transport ships all converged on the beach. “There were so many boats and craft, they all got jammed up and



Sergeant Mike Strank (Barry Pepper) and his men fire on the enemy from behind a berm of black sand. To accommodate Eastwood’s famously quick-paced shooting style, production shot only necessary foregrounds and midgrounds with performers, leaving backgrounds to the visual effects team. In a series of storyboards and Photoshop renderings executed during preproduction, the filmmakers developed a highly subjective and intimate approach to shooting that would present the combat action primarily through the eyes of the combatants, rather than in wide establishing shots.

had a hard time deploying on the beach — and that really happened,” said Owens. “Originally, we had hoped we could sell that idea with the existing real vessels we had; but we found that those vessels were not very maneuverable. If they got too close together, they could have created a dangerous situation. So the configuration of the vessels was not as tight and condensed as it should have been, and that’s why Digital Domain had to fill in those shots. They augmented in between the real boats, putting CG boats right next to the real ones — and you cannot tell the difference between the two.”

The beach landing shots also required that Digital Domain re-create the surf as it appeared in the Iceland live-action plates. Though Digital Domain had used its ‘Storm’ volumetric rendering pipeline, previously called ‘Voxel B,’ to create water effects such as the water horses in *The Fellowship of the Ring* and the giant storm tide in *The Day After Tomorrow*, the company had never been called upon to create photorealistic waves breaking on a shoreline. “This was a very complicated thing to do,” said Matthew Butler. “It’s much easier to do a continuum flow of fluids, where the fluid doesn’t break its shape — and we’ve done that for years. And, of course, we’ve done whitewater effects, for *Day After Tomorrow* and other movies. But this was an entirely new thing. We had to create a normal, typical wave with its specific curling shape; and then, as it hit the shoreline, it had to change its shape and curl in a very specific manner. It needed to look exactly right, because we’re all very astute to the look of a wave breaking on a shoreline. We’ve all seen it thousands of times.”

CG effects artist Greg Duda, a member of Jonah Hall’s team, was a key figure in developing the shoreline surf. “The amalgamation of Storm with the program we hooked into — in this case, primarily Houdini — allowed us to create water behavior that was rendered out as a volumetric,” said Butler. “But that combination, alone, did not give us those curling waves. That was primarily created through Greg’s mathematics. He was really the brain behind our curling water, and our whitewater breaking on the shoreline. It’s got all the photorealistic qualities of continuum flow water, together with breaking whitewater and appropriate animations, speed and behavior such as receding, advancing, ebb and flow. I’m really proud of what they came up with. It is quite remarkable.”

“Digital Domain did a great job in simulating the surf,” agreed Michael Owens. “Not only did they create very realistic looking surf, they also rotoscoped back into the surf that was there in the live-action, so that we could create the interaction of all these watercraft cutting through the ocean. They animated to match the surf that was actually there, so when we put CG boats in the surf, they displayed all the appropriate dynamics and interaction with the real water.”



Digital Domain heavily augmented practical smoke and explosions of black sand – executed on location in Iceland by special effects supervisor Steve Riley and his crew – with digital sand plumes and atmospherics, in some cases replacing those practical effects entirely with CG. A decision to eschew bluescreen on location required Digital Domain to embark on the biggest rotoscoping assignment in its history, as artists placed their CG effects behind and in front of live-action performers.

In the ‘beach battle’ sequence that follows, the landed troops initially meet with an eerie silence. Suddenly, the calm is shattered as Japanese soldiers — sheltered in a series of underground hovels and concrete pillbox structures — initiate a massive firestorm. The combat, as described in Bradley’s book, was horrendously bloody and violent, with soldiers losing arms and legs and heads, and bodies burning in explosions. “It was a terribly chaotic battle,” said Eastwood, “the biggest battle in Marine Corps history. It had the most Medal of Honors given from any battle, and it had the most casualties of any Marine Corps battle. Almost 7,000 Marines were killed, and another 25,000 were wounded in some way, shape or form.”

Although makeup department supervisor Tania McComas and crew, together with Christian Tinsley, were able to achieve many of the dismemberments and other injuries through practical makeup effects, Digital Domain augmented the carnage digitally. “It would have slowed us down too much when we were shooting to deal with hundreds of injuries and dead bodies,” stated Owens, “so they did as much of that stuff practically as they could, given time constraints, and then we added to that in post. It helped that there isn’t a lot of gratuitous gore in this movie. There are a couple of appropriately gory moments; but for the most part, that stuff happens peripherally.”

Digital tweaking was required for a scene in which a soldier — portrayed by Clint Eastwood’s son, Kyle — is decapitated. Production had shot a dummy severed head, which Digital Domain cleaned up digitally, to enhance the realism of the makeup effect. “We put smoke coming out of the neck area,” explained Bryan Grill, “as if it had just been sliced by a hot piece of shrapnel. We also added dripping blood and morphed the jaw to open when a knee hits the head. It looks very real. When Clint saw it, he joked, ‘There have been times I’ve wanted to do that to him!’”

Wider shots of background soldiers flying into the air with the force of a blast, or body parts passing through frame, were all achieved using 3D elements. “There are a couple of areas where whole groups of soldiers are hit by a bomb and you see them being taken out,” said Grill. “Those characters were done using Massive software, with some specific hand-animation overseen by CG supervisor David Hodgins. We also added blood and some 3D body pieces that you wouldn’t necessarily recognize as specific body parts, but look like human flesh.”

Heavy gunfire and explosions kick up plumes of black sand, which Digital Domain artists created through a custom dynamics simulation. The



On the fifth day of the campaign, having taken the wo Jima beach – with massive casualties on either side – a small unit of Marines climbs to the top of Mount Suribachi where they will ultimately plant the American flag. Although no mountain was appropriately situated on Iceland, near the location beachhead, volcanic Mount Arnarfell, situated several miles inland, served as the shooting site for all scenes set on Suribachi.



An American sentry stands watch atop Mount Suribachi. Digital Domain artists replaced the plains and distant ocean below Mount Arnarfell with computer generated ocean, shoreline, boats, military hardware, Massive troops, skies, combat debris and smoke. Aerial shots from a similar vantage point were entirely computer generated.

simulated sand plumes were often inserted into scenes directly beside real-life plumes created by the special effects team on location. “Because these sand plumes were right next to live-action effects,” stated Matthew Butler, “they had to be spot on. We’ve done plumes of smoke before; and, like those, these sand plumes lent themselves to a volumetric approach — but they couldn’t be handled in exactly the same way. The beach in Iceland had very fine black sand, akin to what would be found on the Iwo beach, so we had great reference footage of that sand shooting up with exploding mortars, and we had to match that behavior of fast-moving particulates. CG effects artist Ryo Sakaguchi spent a lot of time coming up with something that matched the exploding sand plumes as they appeared in the live-action.

Atmospherics generated by the battle — dust, smoke and debris — were created through a combination of techniques. “Some were fully 3D volumetric things, achieved using Storm,” explained Butler. “We did that if they were thick elements that we needed to see parallax on. There were other shots where we could just collage together 2D elements. We had a library of photographic elements that had been shot for this movie, as well as photographic elements from past projects, and elements we’ve generated in CG — and all of those were hodge-podged together on a shot-by-shot basis.”

On D-Day Plus 4, after the American troops have taken the beach, a small unit begins its climb to the top of Mount Suribachi. Though production had shot close and midground live-action for the sequence at Mount Arnarfell in Iceland, wide views of Suribachi were created through EnGen. “Our team used EnGen to create the quintessential, iconic look of Suribachi,” said Butler, “which is seen as a volcanic land mass that protrudes at one end of the island. Whenever you see a wide aerial view of Suribachi, it is EnGen. The idea was to make Suribachi look as it would have then. Today, it looks quite different than it did during the battle, because it had been bombed out by the time the guys climbed it. It is much more green and lush now, and there is a road up to the top that has been carved into the terrain, which, of course, wasn’t there at the time. So we worked from photographs both from the period and present day.”

Whereas Digital Domain integrated 3D-modeled elements into most of its EnGen environments, shots of Suribachi often relied on matte-painted enhancements. “The content coming out of EnGen for the top of Suribachi, especially, was fairly nondescript,” said Butler, “and we needed to do quite specific things to that in terms of roads, et cetera. So, in that case, it made sense to apply a matte-painted or photographic projection onto the 3D geometry. We leaned heavily on our matte painters to help us out with that.”

Once at the top of Suribachi, soldiers raise the American flag — but it was not this flag-raising that was immortalized for all time. Rather, Joe Rosenthal famously photographed the raising of a second, much larger flag, later in the day. In preparing to re-create that iconic image for the movie, Owens and the filmmakers studied not only the famous photograph itself, but also an animatic of the event that had been created for historical purposes.

Initially, key production personnel assumed the six flag-raisers in the shot would have to be computer animated in order to re-create their positions in the photograph exactly. Owens disagreed. “I knew we’d probably have to do a CG flag, just to make sure the wind hit it exactly right and it was flapping around exactly as it was in the photo,” Owens related, “but I thought we should

at least try just rehearsing the actors going through those flag-raising actions, and then shoot them. Even Clint, who likes to do things practically, was a little worried. ‘Are you sure we don’t need 3D guys for this?’ But I said: ‘Let’s shoot it and see what we get. We can always go to 3D if we have to.’ So we rehearsed the guys, and we shot a couple of takes — and we got it, just like that. We didn’t worry about what the flag was doing, because we knew we were going to change that in post anyway. But as it turned out, we didn’t even have to do a 3D flag. Later, during a period when we were shooting elements in Barstow, California, we shot a bunch of flags flapping around, with fans aimed at them, and we got one that looked great.”

“The flag dynamics matched the real flag pretty well,” added Bryan Grill. “We had our matte painters just go in to make the flag look more beautiful and match it even more to the flag in the photograph.”

The wo Jima battle scenes are intercut with sequences set in the 1940s and in the present. Modern-day scenes, logically, required only minimal effects, such as the digital removal of arms in a scene in which a veteran of wo Jima who had lost both of his arms in the battle, Walter Gust (George Hearn), is interviewed by James Bradley for his book. Digital Domain also disguised a healthy pulse that could be seen beating on the actor portraying the elderly John Bradley as the man lay dying.

Far more extensive were effects required for 1940s scenes following John Bradley, Ira Hayes and Rene Gagnon — the three surviving flag-raisers — as they headline the “Mighty 7th” war bond tour, which ultimately raised billions of dollars in support of the war effort. Visual effects created period locations representing key stops on the tour, and supplied thousands of Massive spectators in stands and in the streets. One bond tour stop is set in 1945 Times Square in New York, the live-action for which was shot on a partial Times Square backlot set at Universal Studios. “They shot the foreground people there,” explained Matthew Butler, “and then we extended beyond that — a lot. It was definitely worth shooting the principal actors there, but 90 percent of the shot is synthetic. We created that through 3D set extensions and 2D matte paintings; and then we populated it with Massive crowds.”

For other bond tour scenes, Digital Domain created stadiums that no longer exist — such as Griffith Stadium in Washington D.C. — and those, such as Chicago’s Soldier Field, that are still standing, but



Flags of Our Fathers’ nonlinear storyline repeatedly jumps from combat action on wo Jima to wartime America, as the three surviving flag-raisers – John ‘Doc’ Bradley (Ryan Phillippe), Rene Gagnon (Jesse Bradford) and Ira Hayes (Adam Beach) – tour the country promoting the sale of war bonds. One stop on the ‘Mighty 7th’ bond tour is New York’s Times Square, where thousands of citizens gather to see the soldiers so famously captured in the flag-raising photograph.



To create the period scene, production shot lead actors and extras on a partial Times Square backlot set, backed by bluescreen, at Universal Studios. In post, Digital Domain artists generated 3D set extensions and 2D matte paintings to fill the blue matte area with 1940s-era New York buildings. Digital Domain also extended the crowd into the far distance with Massive characters. The visual effects team digitally fabricated several other bond tour settings, as well, including Washington D.C.’s Griffith Stadium and Chicago’s Soldier Field.

look much different today than they did in 1945. As ‘constructed’ by Digital Domain, Soldier Field provided the setting for an early scene in the film. “You see our heroes and flak going off and flashbulbs,” explained Butler, “and it looks like they’re in the middle of war. But then, at the end of the shot, the camera booms up and you realize they aren’t in combat — they’re doing this promotional appearance on the bond tour, and the flashing is coming from fireworks. We filled in all of that environment, the 50,000 people in the stands, the fireworks, the structures — everything but the actors.”

All 500 effects shots in *Flags of Our Fathers* showcase the naturalism and photorealism for which Digital Domain has long been known. “Digital Domain does photoreal like nobody else,” commented Michael Owens. “You look at their work in this movie, and you just can’t believe how photoreal it is. They have done a wonderful job.”

“We didn’t necessarily advance a lot of technologies for this movie,” added Matthew Butler, “but we definitely advanced the aesthetic quality of the work. Because of the very natural way that the movie was staged, because of how photorealistic and believable all of the shots are, the audience will have no idea that there are so many visual effects in it. It will be *Apollo 13* all over again, where nobody realized how much effects work was in the film. But that’s fine. It’s quite a pleasure to concentrate on natural behaviors. I’m proud to do this kind of work.”

That naturalism extended not only to the intermittent battle scenes, but to the period and modern-day sequences that were, to Clint Eastwood’s mind, the real heart of the story of *Flags of Our Fathers*. “This isn’t really a war movie,” Eastwood concluded, “not completely. It is more a movie about being given celebrity when you don’t think you deserve it, and what happens to your life when you’ve been manipulated like that. The Ira Hayes story turned out to be tragic; and Rene Gagnon’s life wasn’t at all what he thought it would be after reaching these great heights of celebrity. John Bradley was the only one of the flag-raisers who was able to have a somewhat normal existence — even though he was constantly affected by the war, too. All of the *Marines* who experienced *Wo Jima* were told to go back home and get over it. Some of them did, to some extent, and some of them didn’t. Ours is the story of both of those types of people — represented by these three men who raised the flag on *Wo Jima*. That’s the story we wanted to tell.”

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Beneath the Barnacles

image

ARTICLE BY JOE FORDHAM

Pirate movies have come a long way since the Hollywood classics *Captain Blood*, *The Sea Hawk* and *The Crimson Pirate* epitomized the genre. Latter-day nautical adventures, including Roman Polanski's *Pirates* and Renny Harlin's *Cutthroat Island*, failed to rekindle movie-goers' interest in swashbuckling; but then, in 2003, Johnny Depp appeared with his swaggering portrayal of rascally Captain Jack Sparrow, star of Walt Disney Pictures' *Pirates of the Caribbean: Curse of the Black Pearl*. Directed by Gore Verbinski, the movie offered a lively mix of derring-do, romance, whimsical references to Disneyland's 35-year-old theme park ride, and spectacular effects that earned visual effects supervisor John Knoll and his team from Industrial Light & Magic an Academy Award nomination.



Having resurrected the pirate movie genre with *Pirates of the Caribbean: Curse of the Black Pearl*, producer Jerry Bruckheimer and director Gore Verbinski returned with a sequel, subtitled *Dead Man's Chest*, that reunited the original's protagonists and introduced a fearsome new adversary, Captain Davy Jones (Bill Nighy). Davy Jones was the principal illusion entrusted to visual effects supervisor John Knoll and Industrial Light & Magic, who collaborated with mechanical effects teams, makeup artists and supporting visual effects vendors to create high-seas spectacle and a host of bizarre creatures, including a crew of lost mariners enslaved to serve under Jones' curse of hideous mutation.

Verbinski and producer Jerry Bruckheimer called on ILM once again for *Pirates of the Caribbean: Dead Man's Chest*, an ambitious sequel that reunites Sparrow with Will Turner (Orlando Bloom), son of a famous buccaneer, and their mutual love interest, Elizabeth Swann (Keira Knightley), daughter of the governor of a Caribbean trading town, Port Royal. The trio and the crew of Sparrow's pirate vessel, the *Black Pearl*, this time run into conflict with the East India Trading Company and a ghost ship, the *Flying Dutchman*, captained by Davy Jones (Bill Nighy), legendary lord of the demons of the deep, whose crew of lost mariners are enslaved to serve under a curse of hideous marine-life mutation. A cannibal island, buried treasure and a sea monster — the kraken — add to the adventure, culminating in a cliffhanger ending that will only be resolved with the conclusion of the series' third installment.



Will Turner (Orlando Bloom) wades ashore on Cannibal Island, where the pirate ship *Black Pearl* is beached. The production shot a large portion of the film on location in the Bahamas using reproductions of 18th-century sailing ships together with partial ship sets built atop ocean-going barges. ILM generated digital extensions to the floating sets and, occasionally, reproduced ships in their entirety using miniatures and digital simulations. For shots of the Pearl run aground, modelmakers rebuilt an existing miniature, updating its design from the first film to match a full-size floating set. Compositors then integrated the vessel into beach scene plates photographed in Dominica.

The two sequels were filmed back-to-back on location in the Caribbean at an abandoned U.S. military base in Freeport, Grand Bahama Island, converted into a studio and water tank. The shoot was interspersed with further studio and location work in Los Angeles, where previz artists from Proof Incorporated and ILM, plus a few freelancers, blocked out action sequences. "Gore spent a lot of time adjusting previz and working with the editors to get it really tight," said second unit director Charles Gibson, who joined the production in its early stages before accompanying the shoot and shepherding postproduction. "Previz was vital because there was so much three-dimensionally staged action high in the ships' rigging and in the boats down below. It ended up being a very important production tool."

To assemble a fleet of 18th-century ships for the film, production designer Rick Heinrichs redressed seaworthy replicas of historic sailing ships and built other vessels as partial set pieces atop ocean-going barges propelled by tugboats or winches, engineered in collaboration with physical effects supervisors Michael Lantieri and Allen Hall.

Conceptual artist Mark 'Crash' McCreery, a collaborator from the first *Pirates* film, contributed designs for the *Flying Dutchman* — a floating mass of bones and sea life — and her similarly ravaged crew, creating black-and-white renderings and color studies that depicted Davy Jones as a bipedal amalgam of pirate and crustacean, with a crab-claw arm and leg and a snout of fleshy tentacles. After tests with makeup department head Ve Neill and her lead makeup artist Joel Harlow, Verbinski and ILM decided that Jones and all but one of his cursed crewmembers should be entirely computer generated.

"We wanted to be able to do things that would be very difficult or impossible to do with makeup or prosthetic appliances," asserted John Knoll. "We didn't want creatures that looked as if they could have been played by guys in suits; so some had holes through them or other aspects that couldn't

have fitted to a performer. But we also wanted to treat the CG characters like any other part of the movie. We felt very strongly that we'd get better results by having world-class actors author performances on set. An actor could work with the director to deliver a performance, the camera operator would have somebody to frame up on, the director of photography would have someone to light, the editor would have a performance to cut — and the visual effects would have no stylistic difference from the rest of the movie.”

Rather than attempt to do on-set motion capture — which would have slowed production — the visual effects team used iMocap, a custom tool developed by director of research and development Steve Sullivan and motion capture technician leads Michael Sanders and Kevin Wooley to procedurally track actors wearing gray unitards marked with horizontal bands around the head, chest, arms, shoulders, legs and knees. “The suits were gray because that was the average color of the characters,” explained Knoll. “Gray had neutral lighting properties and was fantastic lighting reference, similar to our gray lighting spheres — it gave us cues for color, brightness and lighting direction.” Performers in the marker-striped suits would provide underlying skeletal motion, which animation supervisor Hal Hickel and his 62-person crew would then enhance with animated facial expressions and emotional performance.

To capture the iMocap data in studio, ILM utilized high-frame-rate, black-and-white commercial security cameras tethered to a small portable computer, synchronized to the film camera. For location scenes, ILM made use of nonsynchronized battery-powered high-definition camcorders, which provided adequate data to record the performers' positions in confined spaces or open to the elements. Creature performers reviewed conceptual designs to develop appropriate body language for their performances. John Knoll and his team then operated witness cameras, keeping figures relatively large in frame to maximize resolution from vantage points on set. “We set up witness cameras whenever and wherever we could,” said Knoll. “We were totally opportunistic, diving in wherever we could to triangulate the actors' positions in the set. As long as we had a reasonably good view of the targets, and there was a little parallax, it worked pretty well.”

Verbinski shot scenes with as many as 15 gray-suited Dutchman performers who delivered lines and interacted on set, splashing through surf, performing stunts and swordfighting with other characters. Wardrobe artists provided masks for deep-background Dutchman crew to fill out scenes, while makeup artist Ken Diaz and a team of more than 40 artists applied practical makeups for all living pirates. “Gore wanted all the pirates to look like they hadn't bathed in years,” remarked Ve Neill. “We tried many different combinations of products to make them look dirty and to make them stay that way when they got wet or sweaty. We used MAC Face and Body and Full Coverage Foundations for pirates that weren't tan enough. On top of that, we applied washes of Premiere Products' Skin Illustrator colors.”



Native islanders capture Turner and haul him to a jungle village. The production filmed jungle scenes partially in the Caribbean and partially at the disused Marineland amusement park in Rancho Palos Verdes, California. Makeup department supervisor Ve Neill and lead makeup artist Joel Harlow created a variety of intricate makeups for the islanders, based upon Crash McCreery conceptual designs. Artists sculpted modular makeups, then mass-produced prosthetics in Los Angeles and applied them in

To create grimy pirate hair, artists applied varieties of hair wax, gels and K-Y jelly, with instant oatmeal worked into beards of less sanitary characters. Additional detail included blisters, cracked lips and rotten teeth created using dental veneers. “We used a plastic material painted on the inside, which the actors wore like bleaching trays, so we didn’t have to paint their teeth each day. Richard Snell, one of my four main artists, masterminded all our dental work and trained other artists to make veneers for hundreds of sets of teeth.”

ILM enhanced the setting using digital matte paintings to make the composition of the shot more dramatic. John Knoll’s team photographed jungle plates without using motion control or extensive tracking markers, and captured digital stills of scenic rock textures on location. Digimatte artists then reconstructed the environments in 3D, mapping geometry with scenic textures and synthetic painted elements to create jagged mountain peaks and plunging gorges.

Johnny Depp’s personal dentist created several colors of gold and silver dental caps for Depp to wear for the duration of the shoot. For the actor’s exotic eye makeup, Neill used a cream liner imported from India, which acted as a soothing balm while at the same time accentuating Depp’s eyes. Neill also commissioned custom contact lenses from Professional Vision Care to help counteract the glare of the Caribbean sun. Sparrow’s makeup also included a hideous hairy melanoma and Pros-Aide transfer scars and tattoos designed to cover some of the performer’s personal body art.

The most extensive practical makeup devised for the film appears in an early sequence in which Will Turner’s long-lost father, Bootstrap Bill (Stellan Skarsgård), visits Jack Sparrow on board the Black Pearl, introducing himself as a *Flying Dutchman* crewman. “Bootstrap was once a member of the Black Pearl crew,” remarked Joel Harlow. “When they tossed him overboard, he was still alive at the bottom of the sea when Davy Jones came to him and proposed he could serve 100 years before the mast, after which he’d be free, or he could stay down there and rot. Bootstrap took Davy’s offer and, when he became part of Davy’s crew, he started to become part of the ship. The design on the Dutchman incorporated a lot of faces and sculptural body parts, alluding to the fact that people have been absorbed into the ship, and, over the course of *Pirates 2* and *3*, Bootstrap undergoes a pretty complicated makeup transformation from being encrusted to being completely engulfed in sea creatures.”

Based on *Crash* McCreery conceptual art, Bootstrap Bill was the only flesh-and-blood incarnation of the Dutchman crew, providing a visual link between live and digitally generated pirate characters. “The makeup had to blend with the rest of the CG Dutchman crew,” observed Harlow. “So we used silicone appliances, which gave us translucency and flexibility. There were also rigid pieces growing out of him, which we cast out of two-part plastic.” After making lifecastings of Skarsgård’s head, hands and feet, Harlow sculpted the first three stages of marine infestation. “We went to various Asian markets and grabbed oysters, clam shells and small crustacean seafood items. We cleaned them up, made silicone molds and cast a bunch of clay versions. When I was sculpting the makeup onto the cast of Stellan’s face, I added barnacles and shells, knowing I had to remove them and leave sockets. We number- and letter-coded pieces and built it like a jigsaw puzzle. I grouped rigid pieces in small clusters to avoid creating big sheets of rigid material. They all had to move, sharing space on his body.”

Stage One involved a three-piece facial appliance and a bedraggled wig braided with strands of seaweed, created by supervising hair stylist Martin Samuel. Stage Two enhanced Stage One with Pros-Aide transfer pieces and encrustations on Skarsgård's arm. Stage Three involved a more extensive sculpture with larger coral outgrowths, barnacles and a starfish woven into Bootstrap's cheekbone. "The starfish gave us an opportunity to drag his eye down in a puppy-dog look," said Harlow. "The character was not supposed to be menacing. He's more confused and forlorn." Harlow, Neill and Snell applied Bootstrap makeups in two- to four-hour makeup sessions accomplished on dry land before sailing out to set. The silicone prosthetics required minimal touchup and maintenance on set, allowing Skarsgård free range of movement.

Gentle Giant Studios scanned the final application and ILM took photographic reference, which digital artists then used to subtly enhance the character's in-camera look. "We added little animated attachments here and there," commented ILM compositing supervisor Eddie Pasquarello. "We used warping in Sabre to make mussels appear to breathe on his shoulders, with small sea urchins and tubeworms sticking out, and tiny sand crabs crawling around his body. The makeup was fantastic reference in helping us integrate all our fully digital characters."

For development of digital Dutchman crew, ILM art director Aaron McBride referenced McCreery artwork to produce photorealistic studies of 18 hero characters, with variations. "We started with rough drawings to establish primary forms," related McBride. "I scanned those into a computer with a lot of reference photos. It helped that ILM's new facility is located near the water in *San Francisco* Bay. I went down to the piers and took photos of pilings encrusted with seaweed, kelp and barnacles, and grafted those textures into characters, trying to keep in mind the hierarchy of the curse." New arrivals to the Dutchman crew featured low levels of marine encrustation, which then erupted into sea life, before motivating larger physical changes — as displayed in Maccus (Dermot Keany), a hammerhead shark mutation. "One side of Maccus' face still had a human eye, while on the other side his human eye had started to swell shut. Then, on the ends of his hammerhead, one shark eye had opened up and another hadn't fully formed on the other side. We wanted to suggest this was an asymmetrical evolution, like a cancer growth."

McBride built up digital libraries of nature reference, much of it not for the squeamish, including images from the journals of a Caribbean physician who had treated rare deformities of chronic enlargements, acromegaly and elephantiasis, and degenerative skin diseases, such as cell carcinoma, rosacea and acne. A news item about a dioxin poisoning inspired textures for a decrepit crewman known as Clanker (Andy Beckwith). "The poison attacks the liver and leaves the skin pitted and discolored," said McBride. "It was a very interesting texture, so we grabbed reference of that and used it to show how Clanker's skin was starting to distort before erupting into barnacles." Beckwith's performance, slaving his lines, inspired detailing inside his character's mouth. "I found the most horrible shots of people who were avid tobacco chewers. We used those for inside the mouth, replaced his molars with gooseneck barnacles and tubules, and gave his tongue a clam-like ruffled edge, like the inside of an oyster."

Gore Verbinski urged ILM to retain the character traits of iMocap performers even in some of the more extreme mutations — including Kolenico (Clive Ashborn), a spiky puffer-fish faced sailor, and Hadrás (Ho Kwan Tse), a sea slug mutation whose head resided inside a shell. Other crewmen, such

as Penrod (Peter Badalamenti), a manic crustacean character, evolved significantly from conceptual renderings, inspired by performance reference plates. “Penrod was the lackey whipping boy in the crew,” quipped McBride. “He started as a cross between a lobster and a sand flea. We played with the lobster idea and departed from his human form a little to give him the structure of a crayfish. John Knoll suggested we split the characters legs into two smaller lobster-like legs for more asymmetry, while we kept his face human. The actor on set was doing manic little gestures, and Gore wanted to retain a lot of that personality. We also looked at photos of Marty Feldman, the comedian from a lot of Mel Brooks’ old movies who had a thyroid condition that bulged his eyes in a very skittish way, and we incorporated some elements of him into the design.”

Bringing to life the wild designs required a technical shakedown. “In the past, and on *Pirates 1*, we used NURBS surfaces as our modeling tool,” said digital production supervisor David Meny. “For this film, we primarily used subdivision surfaces. Technically, it was a major shift and it took a lot of work to make it happen, while we were pushing the aesthetics.” At the peak of production, Meny and CG supervisor Pat Myers oversaw a team of 97 technical directors with lead sequence supervisor Tom Fejes, who set up ILM’s lighting package, Lux, focusing on subsurface scattering and a new approach to occlusion rendering to more efficiently handle heavily displaced geometry.

ILM creature supervisor Geoff Campbell oversaw a creature development team that used Gentle Giant full-body and head scans of iMocap performers to establish bone lengths and proportions. Modelers sculpted characters in Maya and planed away anatomy to create negative space in creature models, while attempting to avoid making characters too outlandishly inhuman.

The creature crew detailed the characters using Pixologic’s ZBrush three-dimensional sculpting tool. “ZBrush allowed us to paint in displacement on top of subdivision surfaces,” stated Meny. “We could then render with high precision through displacement mapping, or we could turn displacements into bump-mapping to get the look of detailed surfaces without the expense.” ZBrush allowed the creature artists to instance geometry on model surfaces, then select whether to include the model in the creature’s geometry, or use it as a surface map. “We needed that flexibility in adding detail to keep our models relatively light. These were some of the densest character models we’ve ever built at ILM.”

Modelers made field trips to Monterey Bay Aquarium, referenced books on marine life and coral reefs, and gathered flotsam and jetsam from local shorelines to build a sea life toolkit. “Modelers first built the underlying model,” said Geoff Campbell. “Sea life components were added on top of that, building up a reef on each of the Dutchman crew, hand-placing mussels and barnacles on each character, almost like flower arranging.”

Meanwhile, the creature simulation team was creating animation controls to hook into iMocap motion data using ILM’s Maya-based character-building system, Blockparty. “We called it ‘Blockparty’ because it’s like building characters using building blocks,” ILM creature simulation supervisor James Tooley noted. “Our creatures came under the category ‘biped,’ which automatically gave them two arms, two legs and a head. We took that Blockparty geometry, moved it around until it matched our creature geometry, and very quickly chained our models. The standardized blocks automatically brought in all the joints and constraints, and got us 60 percent of the way there. We then added ‘user blocks’ — specific skeletal pieces such as fingers or limbs — which fit onto our main blocks, and did additional rigging by hand.”

The controls connected CG characters to iMocap performances with keyframe overrides. “We used a blended constraint control system,” explained Tooley. “Animators could vary the performance if they wanted different parts of a creature to be more accurate to the actor in the plate. After we baked that performance onto the creature, we had special structures that allowed animators to smooth out the movements or alter them to add to, or accentuate the performance.”

For creature crowd scenes, ILM built additional lower-resolution background-quality sailors using four body proportions, four costume variations and four facial variations to make a total of 64 possible character combinations. The production pared the



To create Davy Jones and his crew, all of whom were festooned with articulated aquatic infestations beyond the facility of traditional makeup effects, ILM developed iMocap, a method of tracking live performances on set, rather than on a motion capture stage. Bill Nighy enacts his role in an iMocap suit — a gray unitard marked with horizontal bands and tracking markers.



ILM extracted facial and body articulation from the markers, which enabled animators — led by animation

background headcount down to 16 variations for the second film, allowing Verbinski to populate the *Flying Dutchman* deck and rigging, while keeping 32 background character variations in reserve for the final installment.

ILM gave all characters lip-sync abilities, despite some unlikely physiognomies. “The original idea was for a handful of our hero characters to have dialogue,” remarked John Knoll. “They were the ones that had something more recognizable as a mouth.

Less prominent characters had much more abstract faces and no dialogue. Sure enough, in the middle of filming, we ended up with a shot where Olgilvey — a guy whose head resembled a big red fan of coral — responds to an order, ‘Ayyyyy, Captain!’ And we had to figure out a way to create that articulation with nothing resembling a mouth. Slowly, one by one, almost every character ended up with at least one line of dialogue!”

Greenbeard (Jason Kakabeen) was one of the *Flying Dutchman* crew’s most elaborate members, made up of chunks of rock strewn with kelp and seaweed. The creature team provided animators with rigging to control the underlying body as a mass of geometric shapes. The simulation team then draped the creature with curtains of hanging vegetation and ran dynamic collisions between seaweed and rock.

Cloth and hair simulations were often woven into characters’ encrustations, requiring pre-simulations to suggest fabric fused with bodies. The creature team fitted pirate costumes to the characters by skinning fabric over bony structures using cloth as part of the creature musculature. “We started our cloth sims at a frame where the costume was pretty much in its original form,” explained James Tooley. “When we ran the simulation, the costume wouldn’t stretch — it moved like fabric caked into the sea life.”

The oldest and most encrusted crewman on the *Flying Dutchman*, Wyvern (John Boswall), appears almost completely fused to the ship’s wooden hull. Verbinski shot the scene with Boswell leaning back against a wall of the set. ILM generated the character breaking free, retaining performer facial details. “The actor had such a fantastic face,” observed Knoll, “that we tried to preserve its shape in the design. Giovanni Nakpil sculpted only the front half of the character, before we built his reverse side. We thought it might be cool if only the front half of him broke free and he left his back half in the wall, with his brain suspended between the front and the back. After I pitched the idea to Gore, Aaron created some new artwork, and that became the idea for the character.”

Featured in approximately 200 shots, Captain Davy Jones was the most elaborate character created for the film, and the first developed at ILM. Aaron McBride initiated digital designs, while Richard Miller in the ILM model shop sculpted a scaled maquette and a full-scale bust from Crash McCreery renderings. “We started work on Davy Jones quite a while before they cast the part,” said Hal Hickel. “To be honest, the way I imagined the character was initially a bit limited. I saw him as a terrific, mean villain, with a lot of gravitas, but I assumed he’d be very stoic and stone-faced. Bill Nighy brought so much to the character — weird humor, tons of odd eccentricities — more, I think, than

supervisor Hal Hickel — to create a detailed digital character driven by Nighy’s performance. After experiments using partial facial prosthetics and makeup applications around Nighy’s eyes and mouth, no shots of Davy Jones in the film used practical elements of the actor at all. Working from a Crash McCreery conceptual design, ILM developed the digital character, incorporating aspects of Nighy’s facial structure, and constructed a 3D model with an animation rig capable of translating the actor’s movements to creature physiognomy, including a mesh of facial tentacles that writhed and interacted with Nighy’s underlying performance. Viewpaint, lighting, rendering and compositing artists then imbued the character with cephalopod skin textures.

any of us had imagined. I figured we'd get through the first couple of sequences with him, and by then would have built up a library of facial animation controls to handle most of the scenes that came our way. But Bill was the man of a thousand faces. In every shot he would make some odd facial expression we hadn't seen before, and we'd stop, and think, 'What's he doing now?'

Nighy unleashed his character on set wearing an iMocap suit and brandishing a gray crab claw prop on his left arm. During preproduction, Ve Neill's team experimented with facial makeup designed to assist a blend with animated facial tentacles. Joel Harlow sculpted a two-piece silicone makeup, textured and painted with a flattened nose and full-facial coverage, for a film test. The makeup was deemed unnecessary, although the final blend with Nighy's face was still to be determined. "Gore was concerned that CG eyes are really hard to do," said John Knoll. "He warned us he was going to be very picky about wanting to see life in Davy's eyes; so he suggested that we use Bill's eyes at times, if the camera was in tight and the CG eyes weren't working." To give ILM the option of retaining Nighy's eyes, Neill and Harlow applied skin coloration in a T-zone around the actor's eyes and nose, with approximately 35 tracking marker dots, allowing digital artists to create a blend, if needed. The need never arose. "We were determined to make the CG eyes look as good as Bill's live-action eyes, and we never had to use the real ones. We achieved that through rendering, Viewpaint, lighting and compositing, making sure to place shadows correctly with realistic reflections. It was all about attention to detail."

To help retain the nuances of Nighy's performance, Aaron McBride modified digital designs to incorporate aspects of the performer's facial structure, shaping more prominent cheekbones and a straight-lipped, pursed muzzle. Modeling lead Jung-Seung Hong constructed the 3D digital model, while Viewpaint supervisor Steve Walton led painting and detailing of skin and eyes, and digital artist Damian Steel supervised look development.

Matchmove supervisor Jason Snell and iMocap technical lead Kevin Wooley led a 16-person team that tracked iMocap performances; the animation team then translated Nighy's performance to the 3D



Davy Jones' crewmembers introduce Will Turner to a high-stakes game of dice on board the Flying Dutchman. Fifteen actors, wearing iMocap suits on set, performed Dutchman crewmen scenes while John Knoll's team captured the action from off-camera using lightweight digital video cameras to triangulate the actors' positions in frame. ILM then developed highly complex CG characters, fusing McCreery renderings with the actors' manic performances. Textures were built from a library of nature reference, ranging from exotic sea life to degenerative skin diseases, and applied to suggest asymmetrical transformations into humanoid marine creatures.



An elderly crewmember, fused to the ship's bulkhead, awakes from his slumber and partially detaches to address Will Turner. Actor John Boswall performed the

model with careful analysis. “We first had to figure out the shapes Bill was making with his face, just technically,” explained Hal Hickel. “But then we also had to try to understand the intent of the acting: what feeling was he conveying? We couldn’t simply reproduce facial movements one-to-one because, although Davy’s eyes and cheekbones and the tip of the chin were pretty close to Bill’s, all the tentacles and the rest of the face weren’t remotely similar. It became an interpretive process.”

scene, leaning back against the set and bending forward to deliver his lines. Impressed by the performance, Verbinski encouraged ILM to preserve as much of the actor’s facial features as possible. John Knoll and his team developed a digital model that retained Boswell’s likeness, but only in the front half of the character, rigging the seaman’s brain to break free and hang suspended between rotted timbers and brittle coral growths.

Jones’ facial rigging relied on underlying muscles to convey emotions that could snap between wildly different poses in a single frame. The lack of a human nose presented the modeling team with the challenge of communicating Jones’ disdainful sneer using an approximation of human muscle behavior. “Jung-Seung sculpted a series of skin-sliding and wrinkling shapes to create believable upper lip motion,” said Geoff Campbell. “Tentacle thickness on the upper lip was nothing like a human lip, so we had to translate what the muscles were doing to communicate his contempt. Bill also tended to pull on the triangularis muscles in his lower lip to bare his lower teeth. He was speaking during those expressions, so we had to work our phonemes and speech patterns around those muscle shapes.”

Lip sync required careful track reading to match mouth positions with Nighy’s spirited delivery. “We tried to think of the mouth as a musical instrument,” explained Campbell. “It was not just about the shape of his lips; we also had to listen for how he was articulating, his suppression of air flow and the way he used his tongue as he enunciated. Bill was playing it with a Scottish brogue, and we had to pay close attention to how he was working lines, over-articulating certain sounds in a beautiful way, to make sure we matched that sound.” Associate animation supervisor Marc Chu acted as Davy Jones’ animation lead, ensuring consistency of performance and guiding use of facial controls.

Davy Jones’ mesh of constantly writhing facial tentacles presented ILM with one of its biggest technical and artistic challenges. Nature reference was scarce, with very little footage available of cephalopods outside their natural habitat. In the end, ILM referenced a 1962 creature feature in which a giant sea monster destroys a Polynesian village. “We found some footage from *Godzilla vs. King Kong*,” recalled Hickel. “It had this real red octopus slithering around on dry land, with tentacles flopping around a miniature set. That was great reference for our modelers and animators; but somehow we had to animate 46 tentacles behaving in this way. They had to rest on Davy’s chest, collide with each other, react to forces as he moved, they had to be alive, intertwining and coiling. Animating all of that by hand would have taken far too long, and it would never have looked right. The idea of trying to describe all that in a simulation became a huge burning pit in my stomach for months — but there simply was no ‘Plan B.’”

The ILM team determined that its dynamic simulation engine could provide procedurally-animated tentacles dangling and bumping into one another — but the system fell short of giving the tentacles their intrinsic coiling motion. “It had to be a procedural motion,” remarked John Knoll. “We had a couple of scenes where the tentacles had to perform as fully animated creatures, but most of the time this carpet of tentacles needed to behave almost like a cloth sim — it had to follow a realistic

physics simulation from a skeletal performance, where all 46 tentacles had to squirm around, not pass through one another, and follow the inertia of Davy's motion. That was far more complex than we wanted to burn an animator's time on, so we adapted our existing rigid-body engine. We added joint motors to create the squirming performance, and made the tentacles slightly sticky, like wet spaghetti, so they would stick to Davy's jacket, but still be able to slide around, friction-free."

Research, simulation and animation teams combined forces to fashion the facial tentacle toolset and dynamic system. "Each tentacle had between eight and thirty little joints that could bend, twist and twirl," noted James Tooley. "Each of those dynamic objects was like a little cylindrical piece of wood connected by ball-and-socket joints; but instead of a ball and socket, they each contained a little joint-motor, and we could turn those motors on and off, run mathematical functions or keyframe animation through them, so they moved and twisted as if they were alive."

Creature technical director Karin Derlich devised tentacle behaviors, conferring with the animation department to produce a library of individual coiling motions. The simulation engine then applied forces to animated tentacles, making them swing about. The simulation team applied a volumetric tetrahedral flesh simulation to add jiggle and vibration, emulating soft tissue, and then added stickiness. "When we ran the rigid body simulation," Tooley observed, "the beard fell straight down and hung off his face in a very uninteresting fashion. To correct that, we decided to simulate tentacle suction using 'stiction,' which is a cloth simulation technique." Derived from 'static friction' — also known as 'instantiated springs' — stiction applies forces resembling tiny springs between objects that bind objects in proximity. "Whenever tentacles stuck to Davy's body, it looked like the suction cups were keeping them stuck on. If he turned his head quickly, some of the tentacles flapped around because they didn't have any stiction; others grabbed onto his body and stayed put. It gave us some really nice compositions."

For scenes where Jones used his facial tentacles to interact with objects on set — in one scene playing a pipe organ and in another manipulating a key on a chain around his neck — the production filmed Nighy miming interactions, occasionally using bluescreen mockup tentacles and rod-puppeted props. John Knoll then shot empty background plates, and ILM rotoscope supervisor Jack Mongovan and his 38-person team rebuilt the image, replacing props with digital objects. "Our paint and roto department often used the clean plate to procedurally restore the plate as best we could," noted Eddie Pasquarello. "We sometimes replaced the entire background. Most of the time we tried to retain actors' shadows or reflections from the performance plate and used our clean plate, paint and roto, or procedural compositing to get rid of the gray-suited actors. Procedural compositing involved tracking in a clean plate, using a rig-removal tool in Shake, or a Zenviro patch. The articulated mattes and plate restorations we did on this film were some of the cleanest work I've seen."

For scenes of characters in water, Knoll filmed iMocap performers splashing through the Caribbean surf. Compositors then layered digital characters over the performers using blends of CG water and practical water, including custom elements of black forms creating drips and splashes in a water tank. To integrate Dutchman crew into a nighttime sequence shot in driving rain, Knoll and his on-set team braved practical rain effects and operated witness cameras with camcorders in splash

bags. Compositors then layered characters with CG simulations of rain traveling over characters' bodies and 2D raindrop impacts.

In addition to the *Flying Dutchman* crew, ILM generated elaborate re-creations of period sailing vessels. As with the first film, the production favored full-scale ships and ship façades on floating barges filmed, as often as possible, on high seas. The marine department used a three-masted Bounty replica, built for the 1962 *Mutiny on the Bounty*, to represent the British merchant ship *Edinburgh Trader*; and the two-masted Lady Washington, previously used as the HMS *Interceptor* on the first *Pirates* film, redressed as the battleship HMS *Endeavor*. Rick Heinrichs modified the *Black Pearl*, built as a barge with a reshaped hull to emphasize the vessel's speed. ILM miniature supervisor Charles Bailey consequently rebuilt the existing 1/4-scale *Black Pearl* employed on the first film, stripping sculptural details, cannons and the capstan, then fitting them to a new hull.



*For Bootstrap Bill, the first member of the Dutchman crew seen in the film, Ve Neill and Joel Harlow devised a multi-stage prosthetic makeup to provide a visual link between the film's live and digitally generated pirate characters. Bootstrap – played by Stellan Skarsgård – was designed to exhibit a gradual transformation throughout the second and third *Pirates* films, becoming more and more encrusted with barnacles and sea creatures until he is fully engulfed. Harlow sculpts the character's Stage 3 appliance in clay on a plaster lifecast of Skarsgård's face, leaving sockets designed to accept rigid castings of crustacean shapes.*

ILM applied selective digital enhancements. “Sailing ships are immensely complex in geometric detail,” observed John Knoll. “All the rigging and the sails in daytime environments needed very complex models and radiosity to get them to look right. That was somewhere I didn’t want to go on *Pirates 1*. We had a pretty short postproduction schedule and really hard shots with our skeletal crew, so we stuck with miniatures because it looked achievable for that script.”

Shipboard action in the sequels required the creation of new CG vessels and a CG Pearl. “The full-size Black Pearl set only went up to about 40 feet,” said Knoll. “The masts extended another 50 feet above that, so whenever we were on deck shooting off the top of the set, we shot 14-foot-tall miniature masts and sails and patched them in. We had more of that on this picture, except this time we also had big, high, wide helicopter shots — and there was no way we could shoot miniature elements for that. It would have required a motion control camera that traveled 1,000 feet, 300 feet in the air! So this time we decided to do all the mast extensions for wide shots with computer graphics, and we used miniatures for the ones on deck. There were not many shots that required a full CG Black Pearl in the second film, but we modeled one anyway because it was useful for a handful of shots, and we needed it for a larger number of shots in the next film.”

To create the CG vessels, ILM hard surface model supervisor Bruce Holcomb traveled to the Caribbean and shot photographic surveys of all full-sized ships, then supervised construction of highly detailed digital models representing tall-mast ships, a Turkish fishing boat, the Pearl and the *Flying Dutchman*. The simulation team fitted vessels with cloth simulation sails, ropes and rigging, and festooned Davy Jones’ tattered sails with organic detail. “We called it seaweed and lettuce,” remarked James Tooley. “It took a long time to simulate because we had large panels of fabric and other bits of junk stitched into the fabric. It all had to move as a second layer on top of the main simulation. It became quite an undertaking just to do the sails on the Dutchman, let alone the 14 creatures standing on the deck.”

The *Flying Dutchman* makes its dramatic appearance breaching like a submarine from beneath the ocean. To create interactive water effects, physical effects used CAD data of the full-scale Dutchman to construct a 1/4-scale steel mandrel representing the first two-thirds of the ship’s hull, then rigged the shape with explosive water mortar effects in the ocean on location in Bermuda. “We pulled the mandrel in and out of the water using construction cranes,” Charles Gibson explained. “ILM then used the waterline displacements as the basis of the breaching effect.”

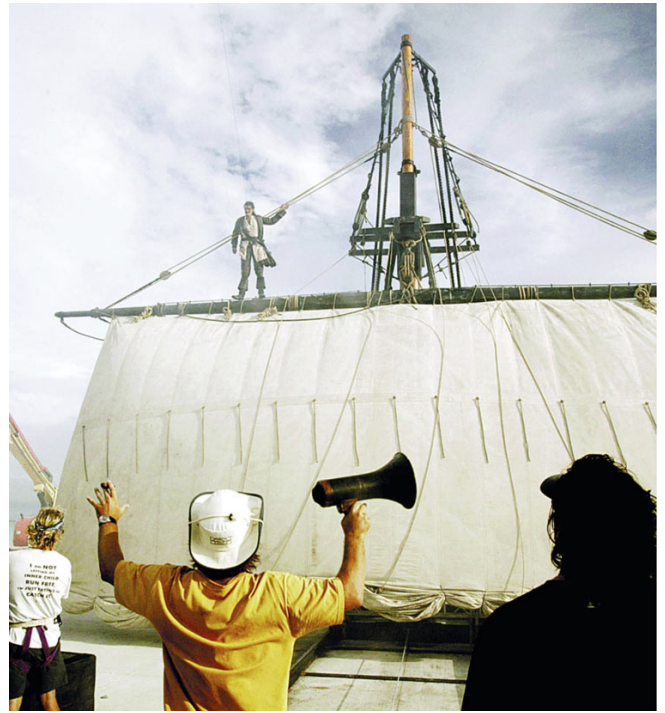


Davy Jones uses a giant crab-claw arm to pin Bootstrap Bill to a mast. Gore Verbinski filmed the interaction on set with Bill Nighy wearing a gray prop claw as part of his iMocap attire. Stellan Skarsgård wore the Stage 3 prosthetic makeup, made up of interlocking flexible silicone pieces, fitted with urethane castings of mussels and clamshells. Gentle Giant Studios scanned the final application, and ILM added subtle digital attachments, warping shellfish to make mussels appear to breathe and animating tubeworms to shrink from Jones’ menacing grip.

The high-seas unit captured as much real photography of water as possible; then ILM combined the elements with digital water simulations, overseen by water simulation supervisor Neil Herzinger, leveraging PhysBAM physical simulations developed concurrently for Poseidon. “Shooting the mandrels as reference in the Bahamas really was a compositor’s dream,” commented Eddie Pasquarello. “The scale and the energy weren’t quite there in the plate, but it was a great place to start and great lighting reference. We used procedural extraction and rotoscoped articulate mattes to pull the white splashes off the black mandrel, and layered the digital ship with CG and practical splashes.”

In addition to oceangoing settings, ILM digimatte supervisor Susumu Yukuhiro oversaw a number of elaborate digital matte painting enhancements of Caribbean environments featured in the movie. The picture opens with Jack Sparrow incarcerated in a Turkish prison, a nightmarish tall tower perched on a pinnacle of rock above a stormy sea. The production filmed manacled prisoners being led into the tower across a precarious stone bridge, shot against bluescreen on a partial set at Universal Studios. ILM generated set extensions as an elaborate nocturnal 3D digimatte environment, blended with live-action scenic elements, composited with passing birds and drifting fog.

Returning to Will Turner’s home of Port Royal, the Black Pearl crew discovers the environment expanded since its last visit. The production filmed the bustling town, its Royal Navy fort and East India Trading Company scenes in sets built on the disused Marineland theme park in Rancho Palos Verdes, California. Digimatte artists extended the setting and collaborated with compositors to eliminate anachronistic details. “We weren’t expecting to see power lines streaming through every tree,” noted Eddie Pasquarello. “When we started looking at plates of the characters on the Port Royal beach, we suddenly noticed we could see more power lines than you ‘d expect anywhere — literally through



Atop the mainsail of the Edinburgh Trader, Turner keeps watch as Davy Jones and his Flying Dutchman threaten to attack the ship. Gore Verbinski and stunt coordinator George Marshall Ruge staged scenes with Orlando Bloom enacting feats of derring-do on a partial set representing the upper quadrant of the sail, oriented against the ocean.



ILM composited the element into high-angles filmed looking down onto the Edinburgh Trader ocean barge, filmed on the high seas in the Caribbean. Deck-level views, shooting off the top of the set, incorporated 14-foot-tall miniature masts and sails patched into shots.

every leaf! It was testament to the skills of our roto and compositing departments that we got rid of all of those.”

The action shifts to Cannibal Island, filmed on the Caribbean island of Dominica. The digimatte department used ILM’s Zenviro toolkit to extend the island vistas, mapping geometry with scenic textures and synthetic painted elements. “Dominica is a beautiful, lush, jungle-covered island,” stated John Knoll, “but it wasn’t quite exotic enough, so we replaced the skylines in a huge number of shots. Susumu and his team added Machu-Picchu-style jagged mountain peaks into a lot of handheld shots where we had smoke blowing through frame and people with straw headdresses running around, creating a lot of difficult roto problems. We shot some scenic rock textures on location, but the rest was a tour de force of the digimatte process.”

The Cannibal Island environment included an action sequence in which Will Turner and Black Pearl crewmembers escape hanging cages made of bones suspended in a chasm. The production shot Turner and his cohorts suspended in cages in a Palos Verdes set with a view of the sea. Digimatte artists extended chasm walls in Zenviro, deepening the gorge and enhancing the ocean view, which compositors layered with articulated roto mattes as the cages swung back and forth. The production shot the remainder of the escape, with actors fleeing through the jungle, in Dominica. Compositors integrated the miniature Black Pearl into wide shots of the ship run aground on the island beach.

Another island setting, Isla Cruces, featured soundstage work filmed on a flooded set on Stage 2 at the Disney studio in Burbank, for a scene in which Sparrow, Turner and their men visit Tia Dalma (Naomie Harris), a shaman who inhabits a shack on stilts in a jungle swamp. Digimatte artists broadened the expansive set for wide shots and compositors enhanced the magical environment with particle animation fireflies, generated in subsequent shots by The Orphanage.

The Orphanage handled additional effects for a scene in which Elizabeth Swann, held captive aboard the Edinburgh Trader, simulates a ghost by marionetting her wedding dress in front of the superstitious crew. The production hung a practical prop dress from wires on set to initiate the scene and as lighting reference. The Orphanage then wrote a shader to emulate the dress’ decorative sheen and developed animation in SyFlex to produce a fluid, ghostly movement unachievable with the practical garment. “We placed high dynamic range images of set lights onto reflection cards around the dress to achieve the backlit look,” said Orphanage visual effects supervisor Ryan Tudhope. “We rendered in Brazil, and simulated several finer cloth details, little tassels of fabric that dangled from the cuffs, on top of the original simulation. We used the lacy decorations on the cuffs as ‘fingers,’ to make it look like the dress was pointing when the wind



Davy Jones dispatches the kraken, an enormous sea monster, to attack the Edinburgh Trader. The physical effects team staged the ship’s destruction using full-scale tentacle splash effects and a breakaway replica of the ship, built in a water tank at an abandoned military base in the Bahamas. Technicians affixed large blue concrete pipes to hinges at the bottom of the tank, lifted the pipes on cranes and released them to impact the ship. ILM also built an eight-foot-long miniature broken hull for the sequence, which compositors combined with CG tentacles and additional live and digital water.

happened to move the arm into a pose in a spooky way; and then, the next minute, it became a real dress again.”

Asylum Visual Effects also contributed to a scene on Isla Cruces, where Turner, Sparrow and Royal Navy Commodore James Norrington (Jack Davenport) fight for possession of Davy Jones’ locker, a wooden chest buried on the island. Stunt coordinator George Marshall Ruge staged the swordplay, working with physical and visual effects departments to follow characters through an abandoned church onto a dilapidated mill wheel, then traveling on the mill wheel as it detaches and rolls toward the beach. Physical effects rigged a full-scale mill wheel to detach on location in Dominica, dropping the 19-foot-tall prop under stunt doubles’ feet with a partial revolution. A small truck then towed a rolling wheel, braced by training wheels, one with water scoops and another without, which stunt performers could ride. Bumps in the road proved a problem for stuntmen on the wheel. “The production ended up removing a lot of vegetation to smooth the wheel’s path,” recalled Charles Gibson. “In the end it was very nearly paved; so Asylum restored the jungle, using 3D plants and full-scale plant elements, so it looked like the wheel was rolling through virgin jungle.”

The production filmed the runaway wheel in three locations, resembling one in the movie. ILM and Asylum removed stunt rigging and poles using articulate mattes, splitscreens and occasional bluescreen elements of performers on the wheel. In the final location, with the wheel at top speed, production filmed a lightweight bluescreen wheel, which ILM and Asylum replaced with a CG version. For a closeup of the wheel rolling over Jack Sparrow, the physical crew rigged a small section of wheel to roll over Johnny Depp. ILM completed the section and used a digital double of Depp as the wheel picked him up and collided with characters on top.

Action then continues from a dizzying point of view trapped inside the wheel, the camera viewing Sparrow and Turner as the world appears to spin around them. The production achieved the shots on location with Depp and Bloom inside the wheel, a camera affixed to the axle. The wide-angle-



Will Turner, pirate Captain Jack Sparrow (Johnny Depp) and former Navy Commodore James Norrington (Jack Davenport) negotiate the interior of a runaway mill wheel while fighting for possession of a mysterious chest, thought to contain the living heart of Davy Jones, found buried on Isla Cruces. On location in Dominica, physical effects technicians staged the action sequence using a full-scale, 19-foot-tall mill wheel, supported by training wheels and towed by a small truck. The actors and their stunt doubles rode the wheel as it rolled downhill through the jungle, the camera braced to rotate with the axle, providing dizzying angles from the characters’ perspective.



To enable performers and stuntmen to safely ride the wheel, the production cleared a path through the vegetation, providing smooth passage across the terrain. In postproduction, Asylum Visual Effects digitally removed stunt rigging and painstakingly restored the jungle, painting out the blue towing arm and training wheels. Asylum then inserted 2D elements of crushing vegetation and digital foreground vegetation lit to duplicate foliage in the plate. And since the plate was shot with a wide-angle lens, the lens dynamics of the practical camera had to be replicated with the virtual camera.

lens perspective of the shot revealed denuded vegetation around the wheel. “That became the most difficult work that Asylum had to do,” commented Gibson. “The rolling shots were so specific to the lens and camera dynamics that we had to restore the jungle entirely in 3D, modeling all that vegetation. And no one will ever know!”

The climax of the movie occurs as the *Flying Dutchman* explodes out of the ocean off the coast of Isla Cruces and stops the Black Pearl from fleeing by summoning the kraken — a gigantic creature glimpsed earlier in the film sinking a Turkish fishing boat and, in greater detail, attacking the Edinburgh Trader, snapping it in two. The production experimented with a practical creature rig on the ocean — towing a partially submerged kraken hump — but instead relied on strategic physical effects for tentacle interactions combined with a fully digital creature created at ILM.

Digital modeler Frank Gravatt created the kraken directly from *Crash* McCreery renderings, devising five separate assets — a full-body creature, a closeup maw and three sizes and scales of tentacles — designed to create the impression of an enormous and infinitely tentacled creature. “The kraken had as many tentacles as necessary,” said John Knoll. “Ninety-nine percent of the time we were just seeing tentacles coming up out of the water, without seeing the body, so we concentrated on building different scales of tentacle and dressed them in as needed.”

Gravatt and lead texture artist Terry Molatare detailed the kraken using ZBrush to create complex displacements. Viewpaint textures included reference of rhinoceros and elephant hide, wetted down, islands of scabby calluses fractured with deep cracks revealing pinker, tender flesh within. “We wanted the kraken to seem like it was thousands of years old,” observed Aaron McBride. “We built up layers with old harpoon scars and dead skeletons caught in the tentacles, maybe from an altercation in the Roman Empire.”

Kraken tentacles consisted of ‘crushers,’ the largest and most powerful limbs, capable of breaking a ship in half; ‘wrappers,’ used for snapping masts; and thinner, noodle-like ‘snatchers,’ used for grabbing characters. Animators strove to convey tentacle mass and power using custom-built control systems. “Tentacles have always been a pain to animate,” said Hal Hickel. “The choices are usually to animate a tentacle at the base and work out toward the tip; but that can be a problem because if you want to change something down near the base of the chain, the movement is amplified in the tip. Alternatively, if you have controllers running the length of the tentacle, that becomes a pain because if an animator wants the tentacle to swing in a big arc from left to right, he has to move all those controllers, instead of hinging at the base. We decided we’d have both types of control.”

The creature rigging team developed tentacle controls using inverse kinematic spline systems — allowing animators to deform mathematical curves representing tentacles, while joints along the curves followed through with dynamic motion — and then further incorporated a posing system. “The posing system used an iterative dynamic solver in Maya,” said James Tooley. “It made sure that distances between tentacle joints remained the same. An animator could sculpt a line using spheres that moved the control points, or they could sculpt the curve with the posing mechanism. The control systems then followed through and intuitively knew where to hit each pose. This allowed us to create poses very quickly, and interpolate natural dynamics.” Additional controls allowed tentacles to stretch and contract by manipulating joints inside tentacle sections. “An

animator could select however many controllers they needed, push a button and start pushing the controls around. They could twist from the tip to the base or from the base to the tip, or twist the middle pieces. We could go down even deeper and have part of the tentacle squash and stretch. We created a lot of controls we have never had before.”

To adorn the flailing tentacles with hundreds of suckers that seemed to roil and contract with organic variation, David Meny designed a Zeno plug-in that allowed animators and technical directors to randomize sucker placement based on a library of sucker variations modeled by Frank Gravatt. “Frank built a tentacle chunk of four suckers,” said David Meny. “He built four sets of variations, which gave us 16 sucker variations — some had been sliced off, some were in halves or quarters, some were bent over. The plug-in then used those as a template and instanced them on a per-shot, per-tentacle basis. We had as many as 12 tentacles in shots, but the plug-in allowed us to create a lot of visual variation relatively cheaply.”

Physical effects created shattering timbers and splash effects, while stunt performers enacted wire gags and ratchet pulls to ground tentacle scenes in reality. Compositors then layered tentacles into scenes with additional debris, smoke, practical and CG water and occasional flying bodies. For the attack on the Edinburgh Trader, full-scale tentacle splash effects were staged using a replica of the ship on a floating gimbal in the water tank in Freeport. “They built huge blue pipes as surrogate tentacles,” explained Charles Gibson. “The pipes were filled with cement, hinged at the bottom of the tank, and we lifted them on cranes and released them to karate-chop the full-scale ship in two.” ILM also built an eight-foot-long miniature broken hull for the sequence, which compositors combined with CG tentacles and additional live and CG water.

In the kraken’s final appearance, which reveals its bulk, Jack Sparrow comes face to face with the creature’s maw. Johnny Depp performed the scene on a full-scale sinking mockup of the Black Pearl, facing air mortars and copious amounts of superslime splattered in his face. ILM sequence supervisor François Lambert then oversaw implementation of the highly detailed digital maw — a funnel-shaped cone of flesh lined with pointed teeth that hinged outward. Frank Gravatt modeled the maw and texture artist Terry Molatore created layers of skin around the mouth, describing orifices within orifices with delicate veined skin based on texture reference of bovine entrails. The simulation team rigged flesh to jiggle and heave as the kraken roars, and enhanced ejecta from the creature’s mouth using slimy fluid simulation. Depp performed his final heroic moments in the film, miming being swallowed by the creature. In a final coup de grace, the kraken pulls the Black Pearl into the ocean, seen



The kraken attacks the Black Pearl, reaching up from either side of the vessel and plucking crewmembers from the deck. ILM developed a full-body kraken, seen fleetingly in underwater shots, and a library of tentacle assets designed to create the impression of a giant creature with a large, but unspecified number of limbs. Tentacles were classified as ‘crushers,’ ‘wrappers’ and ‘snatchers,’ each equipped with a dexterous animation control system. For scenes of crewmembers being snatched by kraken limbs, stunt performers were yanked about by ratchet pulls on set. Compositors then layered digital tentacles into the

in a wide shot featuring the entirely digital ship, blended with live and digital water elements.

shots with additional debris, smoke, water and occasional flying bodies.

The movie concludes by revealing the contents of Davy Jones' locker — Jones' still beating, half-mutated heart, now in the possession of the East India Trading Company. Ve Neill's makeup lab team generated the heart out of silicone, incorporating barnacles and a tentacle wrapped around a slightly oversized human heart. "We made three squishy, floppy dummy hearts," said Joel Harlow. "One was pneumatic and had tubes going into it that we could inflate with bladders. Prosthetic designer Russ Shinkle mechanized another with radio-controlled servos on a little cam, which made it flutter."

The middle chapter in the *Pirates of the Caribbean* trilogy hints at more to come from Davy Jones and, in a final coda, reveals Sparrow's old nemesis Captain Barbossa (Geoffrey Rush) also due for a return, promising further fusion of traditional character design and digital visual effects technology. "I think the two disciplines can make a beautiful marriage when they're handled properly," noted Ve Neill. "The technology is here now, and I think this is the way things are going to be from now on, especially when we are creating characters this complicated in real time. If we can do the makeup and CGI can operate the creatures, it liberates the actors technically so they don't have to have somebody walking around behind them, or underneath them, operating appliances on their face. I'm sure we are going to see more of this technology, and I hope that it won't affect us to the point where we won't ever be able to do makeups again. I don't think that will happen because we will always need the organic touch. I do believe that is important, especially for an actor, because it is very difficult for them to do their job without having something to act with."



Having fled in a longboat, survivors of the attack regard a scene reminiscent of classic sea-monster iconography as the kraken wraps Jack Sparrow's ship in a death embrace and drags the captain and his vessel to their apparent doom. ILM modeled a digital Black Pearl based on photographic surveys of the full-sized set, fitted with cloth simulation sails and rigging, and blended with live and digital water elements. The CG Pearl was also developed for wide shots unobtainable with the partial floating set, and for a larger number of shots in the third, upcoming Pirates film.

With approximately one half of the final film complete, the production is gearing up for a final three-month shoot in Los Angeles and Palmdale, while ILM battens down its hatches for a grand finale to the pirate epic. "It took an enormous investment to make this film work," John Knoll commented. "It took forever to make these characters and to make them look good — but we knew it was going to pay off because we needed them for the third film. There's going to be a lot of stuff that is unique to the final film. We sure haven't used it all!"

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Celestial Alchemy

image

ARTICLE BY JOE FORDHAM

In 1998, a mysterious film poster featuring the Greek letter ‘Pi’ began appearing on billboards around New York City, announcing the arrival of an imaginative and philosophical science fiction thriller. Shot in Super 16 black-and-white, for a budget of \$60,000, the movie marked the auspicious debut of director Darren Aronofsky and a close-knit group of associates from Harvard University and the American Film Institute.

Aronofsky and producer Eric Watson subsequently formed Protozoa Pictures and produced a \$4.5 million sophomore feature, an intense adaptation of Hubert Selby Jr.’s novel of drug addiction, *Requiem for a Dream*. Protozoa spawned Amoeba Proteus as a microorganism of the company — a creative think-tank located in adjoining offices in *Manhattan*, where visual effects designers Dan Schrecker and Jeremy Dawson generated visual effects for *Requiem* and later began exploring designs for Aronofsky’s third and most ambitious project.

Written by Aronofsky and Ari Handel, the new film would follow one man’s quest for love and the *Tree of Life* — legendary source of eternal life — intercutting scenes of Spanish conquistador Tomas Creo during a bloody expedition five hundred years in the past, scientist Tommy Creo desperately seeking a cancer cure in a present-day research laboratory, and star-traveler Tom Creo in outer space, five hundred years in the future, with the same star-crossed lovers appearing in all three time periods.

The story grew out of themes personal to the director. “When I turned 30,” recalled Aronofsky, “both my parents were diagnosed with cancer within a month of each other. That started me thinking about the emotional aspects of coming to terms with mortality, and I started reading a lot about the subject. I found it interesting that in the West there is a constant search for the Fountain of Youth. It’s a youth-oriented culture, and old people disturb us. In other cultures, there is more respect. In Eastern writings, there are philosophies about coming to terms with death, which ultimately is about coming to terms with life — death is part of the living process, part of growing up.” Aronofsky’s research influenced the creation of a screenplay, eventually titled *The Fountain*, which defied genre boundaries as part love story and part meditative science fiction.

Warner Brothers greenlit the \$80 million production with an international cast, including Brad Pitt as the Methuselah-like hero and Cate Blanchett as his muse. Early development included reconnaissance surveys of potential locations in Guatemala, set construction at Warner Roadshow Studios in Queensland, Australia, and visual effects research initiated by visual effects designer Kevin Tod Haug, further developed by visual effects supervisor Micheal McAlister, alongside Dawson and Schrecker. “Darren knew from the very beginning that he wanted to use as much ‘shot’ material as possible,” stated Jeremy Dawson. “He didn’t want to use computer graphics. He wanted visual effects to be timeless, using older techniques and processes, like those in *2001: A Space Odyssey*; and so we started looking into the work of experimental filmmakers, handmade animation and biological research.”

The desire to use filmed elements arose out of a reaction to recent trends in visual effects technology. “CG can be a powerful tool,” observed Aronofsky, “but I do think we are currently experiencing an anti-CG backlash. Audiences have now seen so many digitally generated images, they can very easily distinguish between what looks real and fake, and effects-heavy films can look dated very quickly. One hundred years of filmmaking have shown we are all still watching Charlie Chaplin and Buster Keaton; and when Keaton runs across a train and does an incredible stunt, it’s still an incredible stunt to this day. In my view, film is not a disposable commodity. That’s why I did not want ‘disposable’ effects. That’s why I wanted everything in this film to be photographed.”

Research into ways of realizing cosmic vistas in-camera led the filmmakers to Peter Parks, a specialist in the macrophotography of liquid chemical effects and co-founder of Oxford Scientific Films, whose otherworldly imagery was featured in *Superman: The Movie* and *Altered States*. Now operating as Image Quest 3D in Oxford, England, with satellite studios in Australia and Bermuda, Parks was ideally suited to investigate the creation of unique cosmic imagery via aquatic microparticles.

The production experimented with Parks footage filmed for Richard Edlund’s Boss Film production *Solar Crisis*, which hinted at the possibilities of the medium. “We used Peter Parks’ elements to create the nebula and outer space, as well as views that our character sees through his microscope in the lab,” remarked Dan Schrecker. “Darren’s idea of going small and shooting liquid effects gave us a look that people hadn’t seen before. Thematically, the story was about this character, whose wife is terminally ill, trying to conquer disease, while at the same time going through a journey in the future, which was also partly an internal journey. It created a big loop, from the tiniest minutia to the bigger cosmic questions in the story.”

Themes of birth, death and rebirth took on ironic meaning in October 2002 when, six weeks before the start of principal photography, Brad Pitt departed the film and the production collapsed. “It was a near-impossible task to get the project going again,” Aronofsky admitted. “I tried to work on something else; but, after seven months, I woke up one night and was sitting in my office, staring at all the books I had read to do research for *The Fountain*, and I realized that even though I was developing other stuff I was excited about, I was closer to getting *The Fountain* done. I knew the material so well I just had to see it through. I realized I am an independent filmmaker; I started out making ‘no budget’ films. So I asked myself: Now that I was not writing for actors and I was not writing for the studio, but only writing for myself, what was the ‘no budget’ version of *The Fountain*?”

Two and a half weeks later, Aronofsky presented Eric Watson with a version of the script that the producer deemed more poetic, more beautiful — and possible to make for \$30 million. Watson and Aronofsky regrouped the Protozoa team — with Dan Schrecker and Jeremy Dawson as visual effects co-designers — and drew up plans to remount the show in Canada, with financing from Warner Brothers and New Regency.



Revised plans cut back on the action sequences, but retained many of the techniques explored for the earlier incarnation, maintaining Aronofsky's brief to shoot as much as possible in-camera and use digital effects sparingly to assemble elements. Production designer James Chinlund made strategic use of Montreal locales for a handful of exterior locations and constructed sets at Mel's Cité du Cinema in Montreal representing 16th-century Seville, Mayan jungle settings, contemporary interiors and a surreal spaceship interior. New Deal Studios produced miniature elements, special effects supervisor Louis Craig and floor manager Mario Dumont of Les Productions de l'Intrigue supplied mechanical effects, and makeup effects supervisor Adrien Morot of Montreal's Maestro Studio handled prosthetic and makeup effects.

An intimate drama spanning a thousand years and three time periods, The Fountain follows one man's quest for love and the legendary source of eternal life. First conceived as an \$80 million mega-production, the project floundered and was reborn as a comparatively modest \$35 million venture, financed by Warner Brothers and New Regency. The cycle of death and rebirth that lay at the heart of the film inspired a back-to-basics approach to visual effects – espoused by filmmaker Darren Aronofsky and effects designers Dan Schrecker and Jeremy Dawson – that favored in-camera illusions, photochemical starfields and spare, but artfully employed digital effects.

Warner Brothers visual effects producer Mark Soper joined the production to develop a strategy to manage the digital effects work. Though the filmmakers had developed tests and previz with Mike McAlister for the original version of the movie, the redraft had a budget that was reduced by 50 percent, much of that achieved by cutting the visual effects work. The revised approach to the film mandated a revised approach to the effects; but, fortunately, the production team was not starting from scratch. "It was really helpful that Darren had a binder with a written shot list and an overview aerial diagram of every camera setup," said Soper, "which gave us a clear idea of what he was going to do."

Amoeba Proteus developed Maya 3D animatics of visual effects, focusing on space scenes, and explored options for placing the film's performers, now Hugh Jackman and Rachel Weisz, into the spaceship set — a circular terrain containing a 40-foot-tall withered tree that, in the picture, would appear to be encased in a large transparent sphere with no evident means of propulsion. "At one point Darren told us he didn't want to shoot his actors on a greenscreen stage," Dan Schrecker related, "so we looked into getting a huge high-definition video projector and projecting environments behind the actors to save on compositing." The film's narrative structure — interweaving past, present and future time-lines in a fluid, stream-of-consciousness fashion — made in-camera projection impossible. "It would have forced us to figure out all of our backgrounds for every shot before we got to set. It would have been a complete disaster. But we also tested rear-screen greenscreen projection, using a video projector to project greenscreens. We took those elements, along with Peter Parks' *Solar Crisis* footage, and sent that out as a package to a number of effects houses as tests to see who understood what we were trying to do, who could come up with something that was magical and in line with the effects Darren was trying to achieve."

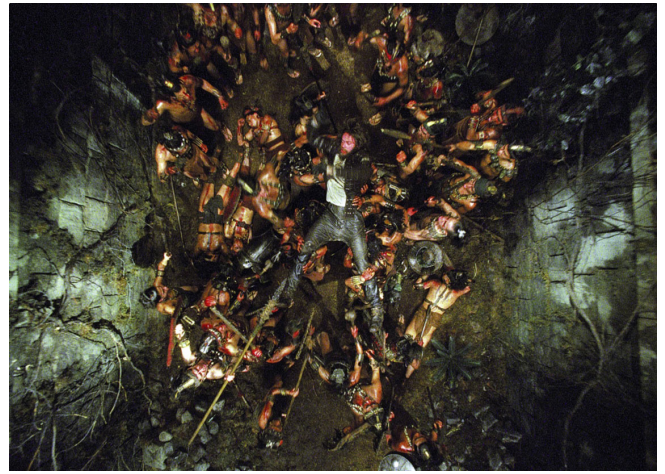
In addition to re-employing Image Quest 3D to create galactic fluid effects, the production assigned work to ten digital effects vendors — although the majority of work, including nearly all the space scenes, would be handled at Intelligent Creatures in Toronto. "We'd worked with Intelligent Creatures once before," remarked Jeremy Dawson. "Dan had a good experience with them; and, of all the people we tested, they seemed to get what we were doing. Other vendors wanted to re-create Peter Parks' footage in 3D, to give us more control. We knew we could do that, but we were following

a brief. We knew using real elements wasn't going to be easy; but Darren said, 'Let's commit to that and see what happens.' And we all got on board."

In shooting space elements for the project, Image Quest built on its vast experience with computer-controlled camera rigs, macrophotography and a panoply of imaging formats — from stereoscopic 15-perf 70mm Imax 3D to high-definition digital. "We have always invested in front of the film plane," said Peter Parks. "We build a lot of our own optics, working with a colleague in Australia. It also has not been a problem for us to embrace the digital revolution. My son, Chris, who is now 34 and is a digital wiz in his own right, has worked shoulder-to-shoulder with me for the last 10 years. Between us, we are progressing towards what will clearly be a totally digital world within a few years."

For *The Fountain*, Image Quest used optics derived from a 150-year-old brass-mounted Ross microscope condenser system, first employed in Parks' earliest experiments at Oxford Scientific Films. Lenses were trained on particulate matter held in solution on an optical bench lit using a technique known as 'dark field illumination' — pinpointing microscopic subjects in a cone of light against a void of pure photographic black. Parks' team spent four months engineering existing equipment into rigs tailored to capture the dynamic flow patterns of microscopic particles resembling cosmic events. Image Quest adapted an optical bench from its standard tabletop horizontal configuration to a vertical system, enabling a wider variety of camera configurations, and made use of a second stereoscopic camera axis to mount a digital still camera at 90 degrees to the film camera. "The stills camera could monitor reactions as they occurred," Parks explained. "It also gave us resolutions that *Amoeba Proteus* used to explore imagery before we started spending more serious money running film."

To create motion in particulate matter, fluids were filmed utilizing a variety of techniques. "A lot of the effects depended on gravity," stated Parks. "Gravity could be in the form of objects simply falling — objects with less density floating to the surface of more dense solutions, or objects with more density sinking into less dense fluids. When we wanted action to cross the field of view, we shot on the horizontal optical bench, looking into the side of glassware where the events were taking place. All our optical systems have very high-resolution 10:1-power focal zoom optics — probably some of the most expensive optics in the world, which we pioneered for the Imax 3D macro/micro field. These gave us the ability to 'fly' towards objects drifting down from top of frame; so, as we zoomed, it created the effect of flying through a snowstorm. We sometimes propelled material towards camera, or partly towards camera, or had objects fly away from camera. Other effects were better



In Central America, 1525, Spanish conquistador Tomas Creo (Hugh Jackman) leads a doomed expedition into hostile Mayan territory. Aronofsky and production designer James Chinlund scaled back earlier plans to depict an expansive skirmish with a Mayan army and, instead, contained the battle inside a claustrophobic set based on a Mayan ball court. Maestro Studio provided makeup effects on set, while Digital Dimension supplied postproduction crowd replication and digital spear hits. For shots wider than the minimal set allowed, Mokko Studio digitally extended the ball court walls, adding jungle vegetation.

seen from beneath, or from above, which is where the vertical system came into its own. Nearly everything we shot for Darren we shot on the vertical system.”

The materials used in solutions included blends of brewer’s yeast, curry powder, milk, water, and oil-based, water-based and powder-based paint pigments. “We’ve learned by experience what will work for us,” remarked Parks. “Specific gravity, density and weight of the material are the most important factors. Temperature can also affect results.” Screen-filling images derived from miniscule volumes of fluid. “The optical system is designed to go from about a five-inch width of field down to literally so small you can’t see it with a naked eye. For The Fountain, we were mainly working in the half-inch realm, sometimes wider, with depths of a few inches; but we often looked a lot closer, a few millimeters deep, with liquid volumes that were eggcup-size, or thimble-size, downwards.”



For views of Tomas scaling a massive Mayan pyramid, the production built a flight of 20 steps leading up to the stone temple summit. Mokko Studio – which generated digital matte paintings for all wide shots in the Central America segments – extended the staircase, added rainforest vistas and capped the setting with a canopy of stars. Scenes shot within the pyramid summit set featured a stone portal backed by greenscreen. Mokko extended the crumbling architecture and generated the surrounding jungle using Guatemalan scenic material, layered with drifting mist.

Macrophotography employed high intensities of light in the t/132 exposure range, requiring camera operators to wear dark glasses while working. Parks operated alongside longtime camera assistant Simon de Glanville, with digital assist by Chris Parks, who monitored frame rates and helped maintain depths of field sometimes measuring only fractions of millimeters.

Operators controlled liquid feeds and focus, using the camera viewfinder more often than less-detailed video monitors. “We were sometimes working with a focus system that was nothing more than a micrometer screw thread on roller-bearing tracks,” stated Parks. “If we were at high magnification, we sometimes focused by leaning against the superstructure of the rig, which squeezed the camera towards the object by a half-millimeter and worked magically. At the end of the shot, we could then relax and the image would go soft-focus, which was sometimes an effect we wanted. There was a level of alchemy with this technique. We learned how to predict reactions, but I also came to realize we were working on a much vaster scale than we could ever fathom — there are parallels in science between micro-particles and cosmic effects that reflect similar laws of physics in flow patterns and turbulence. Sometimes the results were absolutely mind-blowing.”

After a week of receiving digital still imagery of galactic fluid effects and experimenting with imagery at Amoeba Proteus, Dan Schrecker joined the shoot in England. “It was a bit like shooting in the dark,” Mark Soper remarked. “We could go after certain looks, but we couldn’t guarantee we were going to get them. So Dan flew out to Peter’s studio to look into the petri dish as the events were happening, so he could zero in on certain aspects of the reactions.”

A video test shoot was followed by six weeks of film work, which netted more than three and a half hours of footage. Amoeba Proteus then embarked on look development, selectively scanning imagery with Intelligent Creatures. “We had a couple of concept artists in Montreal cutting and

pasting and playing with the footage,” said Jeremy Dawson. “We showed the tests to Darren and James Chinlund, brainstorming as we were going, and started to get a few images that everyone was excited about. Intelligent Creatures then took it to the next level with their artists. We output their tests to film, and everybody breathed a huge sigh of relief! Finally we felt we were going to be able to make something that Darren would be happy with.”

The film opens in Central America, 1525, where Spanish explorer Tomas Creo (Hugh Jackman) leads an expedition toward a Mayan temple, and is subsequently engaged in battle with the Mayans. “We were originally planning a much bigger battle,” recalled Aronofsky. “I wrote that scene on the tail of *Braveheart* and *Gladiator*; but, after seeing all three *Lord of the Rings* films, the desire to do a big battle scene went out of my head. Since then, I realized audiences really weren’t going to get excited by big battle scenes anymore. What might excite people, I felt, was if we focused on one man, Tomas, versus an unbeatable force of Mayans — which is what our character in the future was trying to do, to overcome death.”

The sequence depicted the Mayan city as a claustrophobic maze of ancient stonework shrouded by dank, dark jungle. James Chinlund built the Mayan set in a snowbound soundstage in Montreal, designing the approach to a flight of pyramid steps based on an ancient Mayan ball court. “We only had a budget to do a few matte paintings and extensions,” noted Jeremy Dawson, “so James built three tree canopy set pieces to overhang the top of the Mayan ball court set. Each tree was on a dolly so we could slide them into position to cover whatever we didn’t want to see. We then did extensions where needed; but, in general, Darren tried to shoot characters within whatever environment we had.”

For shots of Tomas ascending the pyramid steps, Mokko Studio art director Mathieu Raynault extended the soundstage set to the temple summit with a digital matte painting. For a wide shot of Tomas on top of the pyramid, Aronofsky filmed Jackman against greenscreen at a doorway entrance. Mokko Studio then generated a jungle vista beyond, referencing Guatemalan scenic material, and extended the pyramid structure beneath a night sky full of stars.

To create the Mayan army, the production flew in 40 Guatemalan natives. “Our Guatemalans didn’t speak a word of English or Spanish,” related Dawson. “When they got off the plane in Montreal they saw their frozen breath for the first time. I was also second unit director, and we had them doing death falls, getting conked on the head, stabbed with swords, and they threw themselves about with no pads, falling about and having the best time! They were amazing.”

Maestro Studio created scarification makeups and prosthetic gore effects for the Guatemalan performers and for a second tier of local extras who filled out the Mayan charge. Digital Dimension visual effects supervisor Michel Heroux and compositing lead Charles Granger enhanced the mêlée by digitally sampling Mayan extras from alternate plates and blending them into the scene, and added 3D flying spears that brutally slammed into the conquistador invaders, as well as digital sword blades that snapped and pierced Mayan flesh.

Inside the pyramid, a Mayan shaman, Lord of Xibalba (Fernando Hernandez), attacks Tomas with a flaming sword. Intrigue Effects created the flaming sword effects practically, using a prop sword fueled by propane fed from below frame. For briefer wide shots, Intrigue Effects used a version coated with pyrotechnic gel.

The story leaps a thousand years into the future, where Tom Creo is seen in closeup — bald, in lotus position — meditating on his past, floating in zero gravity inside his spaceship. The camera pulls back to reveal the spherical transparent ship containing Tom and a withered tree hurtling toward a golden nebula. Aronofsky staged zero-gravity effects with Hugh Jackman submerged in a Montreal community swimming pool attached to Intrigue special effects rigs. “Hugh trained for months to learn how to do a lotus position underwater, holding his breath for about a minute at a time,” related Dan Schrecker. “We shot him assuming a variety of yoga positions attached to what was basically a barbeque spit that Intrigue rotated by hand. We shot him straight on, from the bottom looking up, from the top, and we shot him rotating coming out of lotus position.”

Underwater cinematographer Pete Romano illuminated the zero-gravity elements using Hydroflex aquatic lighting units and a white backdrop behind the performer in the pool. In the spaceship reveal, the camera moved 90 degrees from medium closeup to extreme wide shot, as Jackman performed a gentle jackknife move to land on the ground. The actor then repeated the move for every one of the 20 takes it took to get the shot. “Most films might have used a CG guy at a certain point in a camera move like this,” observed Jeremy Dawson. “Darren wanted to avoid CG, so we stop-watched it out with Hugh Jackman underwater on the barbeque spit as we pushed Pete Romano around on his dolly. Intelligent Creatures matchmoved the shot and put it all together, with a pullback through the surface of the ship, using all shot elements.”

Filmed elements included a 1/10-scale miniature of Tom’s withered tree, built by New Deal Studios based on the full-scale set. “We had to match every plant and decaying piece of wood,” stated New Deal visual effects supervisor Matthew Gratzner. “We built a steel frame, sculpted an inner core, and then molded and cast tree bark scaled to the miniature. We took molds from pieces of driftwood, manzanita branches, pieces of cauliflower and other bizarre plants. We made castings in urethane, de-molded them while they were still soft, and stretched and wrapped them around the core of the tree, then seamed them with modeling putty.” New Deal crew chief Aaron Haye and his team dressed the seven-foot-tall tree into a miniature terrain depicting the tree’s roots growing out and crawling up the inner surfaces of the spherical ship. “We sculpted a big foam hemisphere and then dressed it with real root pieces, weird fungi, a stag-nating pool of water and weird grasses matched to the set.”

Modelmakers fitted the tree ship miniature with mounts on the side, top and bottom, for different flight configurations. For the spaceship reveal, New Deal director of miniature photography Tony Cutrono shot the miniature mounted on its side and utilized matchmove data derived from the



Five hundred years in the future, Tom Creo (Jackman) journeys through space in a surreal starship – a transparent sphere containing a withered tree – en route to a nebula revered by ancient Mayans. To generate the progression of cosmic vistas in constant view around the ship, Aronofsky urged his visual effects team to explore in-camera processes similar to techniques employed in pre-digital science fiction classics. Final composites consisted of macro-photography of liquid nebula effects created at Image Quest 3D in England, assembled using painterly digital techniques at Intelligent Creatures in Toronto.

underwater photography to shoot motion control passes against bluescreen, using a motion control modelmover to rotate the miniature through frame.

To create photographic elements for starfields, Image Quest used liquid formulations drawn from its stock chemical supply. "It was difficult for the CGI guys to produce the kind of randomness that Darren wanted in the color, size and shape of stars," said Peter Parks. "We were able to create that relatively easily using some peculiar particulate material produced for us by a Japanese paint company for a television commercial. We found materials in which the particles would suspend themselves with neutral density and other materials in which they would sink, and introduced color. We used such small amounts each time, we've got a bottle of this stuff and it will probably last us the rest of our lifetimes!"

Used to breathtaking effect in an early montage in which Tom is seen in silhouette practicing t'ai chi, the liquid suspension produced a lush and magical spread of stars. Intelligent Creatures assembled starfields employing a multi-layered track-and-stitch technique. "Darren didn't want simple dots in space," said Intelligent Creatures visual effects supervisor Raymond Gieringer. "We did tons of tests with the microbiology footage, multi-layering elements, displacing them, projecting them onto spheres and different pieces of layered areas. We looked through hours of projected footage, and the depth and color of the elements were amazing. It was like a cosmic jigsaw puzzle."

Digital artists built starfields in Eyeon Software's Digital Fusion, layering background, midground and foreground elements, decelerating footage and sampling details to create illusions of depth. "Shots where the ship was traveling towards camera were particularly tricky," observed Intelligent Creatures associate visual effects supervisor Jamie Hallett. "We used grid warping and pulled elements apart to bring particles through frame as the ship was traveling, and then built in parallax one piece at a time, layering everything in 2D."

The only 3D starfield effect involved subtle refraction and reflections across the surface of the ship. "The idea was for the ship to have perfect optics when we were inside looking out," Gieringer



Jackman enacted space scenes in a bowl-shaped set that contained a 40-foot tree, surrounded by greenscreen.



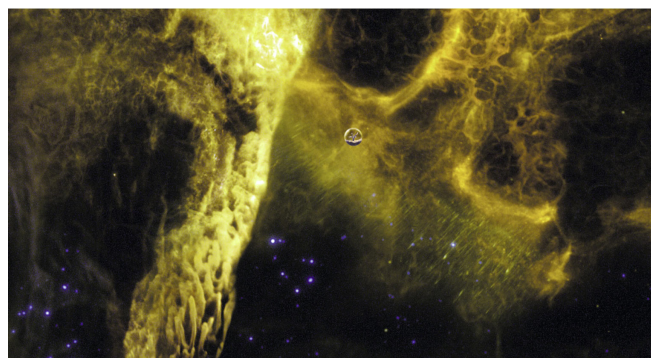
As part of the brief to create visual effects using little or no computer generated imagery, wide shots of the spaceship traveling through space incorporated a 1/10-scale miniature built at New Deal Studios. Modelmakers sculpted the withered tree over a steel frame, and clad the structure with urethane tree bark molded from natural organic substances. Dressed into a foam hemisphere terrain, detailed with roots and grasses, the miniature was shot on a motion control modelmover against bluescreen.

related. “But outside the ship, looking in, Darren allowed us to see some sense of its form against the backgrounds.” Artists digitally projected cosmic environments into a 360-degree dome and projected the image back onto a 3D sphere, creating a sense of the environment interacting with the ship — as seen in the spaceship reveal. “We didn’t have very many options to show the shape of the sphere with reflections of the stars,” said Hallett. “We used a very subtle refraction as the camera moved out through the ship’s clear spherical membrane and distorted the stars just a little to create a sense of the sphere without losing any detail of the tree or Hugh Jackman inside the ship.”

The final composite of the ship reveal included a digital face replacement of Hugh Jackman tracked to the actor’s underwater footage. “There were certain performance beats that Darren had to hit for story purposes,” said Dan Schrecker, “so we shot a number of face replacements with Hugh against greenscreen. Intelligent Creatures digitally projected those onto geometry of Hugh’s face and degraded the image to match the underwater footage.”

Inside the spacecraft, Tom observes his passage through the stars, which appear to cascade down around him beyond the ship’s transparent surface. Director of photography Matthew Libatique filmed scenes with Jackman on the tree ship set surrounded by a movable 270-degree curtain of green- or black-screen material, and choreographed light sources as suggested by on-set visual effects reference material. “We were well underway in designing the spaceship backgrounds when we started shooting,” observed Raymond Gieringer. “When Matty was designing the lighting on the spaceship set he took digital stills, passed them to Jamie Hallett, who was on set full time, and we did test comps with hero backgrounds. This meant that Matty was no longer simply lighting against green. He had a very good indication of the stars’ configuration, so he could play that lighting off the tree and the actors on set. It was one of the most valuable experiences I’ve had with a director of photography. It was a true collaboration.”

Lighting cues became increasingly dramatic as the sequence progressed, taking Tom closer to the dying star, emitting its corona of golden gases. Libatique used chaser lights to create shifting patterns of light showering the ship, and ratcheted exposures to create powerful in-camera effects. “Matty blasted the set about five stops overexposed,” commented Jamie Hallett. “The ship was rotating constantly as it approached the nebula, so he had chaser lights on a rig traveling in a circle. We later slaved our background elements to that lighting; so as light swooped across the tree, our backgrounds moved in sync.” Compositors blended foregrounds with background imagery using shallow depths of field and blooming effects to simulate bright light sources eating into foreground layers. “We tried to maintain good greenscreen separations, but Matty didn’t want to have to push



Creo's spaceship ascends toward slowly drifting tendrils of the golden nebula, Xibalba. Intelligent Creatures assembled the shot using the miniature spaceship composited with subtle digital refraction to suggest its protective sphere, layered into a background created from a library of galactic fluid effects filmed in England. Image Quest 3D created elements by filming bits of yeast, curry powder, milk, water, and various paint pigments held in solution. Lit using a technique known as 'dark field illumination' – pinpointing microscopic subjects in a powerful cone of light – the elements created illusions of cosmic scale.

the image too far in post, so he built all of that overexposure into the negative. He was adamant about matching lighting to the environments.”

Intelligent Creatures built hero spaceship backgrounds using selected 2K and 4K scans of Image Quest footage, then passed pre-rendered material to compositors who layered backgrounds into scenes. “We used each hero background to do groups of shots,” stated Hallett. “Compositors punched in for closeups or medium shots, taking what they needed from the hero background without composites getting too heavy, then added tiny details, extracting elements from the background plate.”

Tom Creo’s space-bound journey included strange rituals as he interacts with the dying tree at the center of his ship. For macro-focus shots of his communicating with the tree, Maestro Studio reproduced a closeup section of the tree trunk with tiny blond hairs on the bark that rose and moved in response to touch. “We molded a foot-and-a-half square of the tree,” said Adrien Morot. “We poured up a skin out of self-skinning polyfoam, placed it on a fiberglass core drilled with one-inch-diameter holes, then punched in nylon synthetic fibers as fine as mohair through the polyfoam, so that it looked like hairy bark. We tied knots in the fibers sticking out the back and braided them to metal clamps.” Mechanical engineer Nelson Da Costa then connected a high-powered flocking gun to the clamps, which ran a positive electric current through the hairs. “We grounded Hugh with negative charge. When he brought his finger close to the bark, all the hairs rose up and as he moved his finger, the hairs did a beautiful little dance, following his movement.”

Maestro Studio also created an edible food substance for the scene as Tom takes sustenance from the tree by breaking off small fragments of bark and eating them. After experimenting with chocolate, which tended to melt in the actor’s hand, Morot’s team concocted edible pieces by grinding up Alka-Seltzer tablets, compacting the powder into bark molds, and airbrushing the brittle, water-soluble fragments with food coloring dissolved in alcohol. The material sizzled mysteriously on Jackman’s tongue, and the actor could safely swallow.



Image Quest 3D founder and special effects supervisor Peter Parks lines up a macro-focus fluid effect assisted by digital supervisor Chris Parks. Image Quest engineered a vertical optical bench using optics derived from a 150-year-old brass-mounted microscope condenser system that Parks has employed since his earliest macro experiments as co-founder of Oxford Scientific Films. Operators introduced fluid volumes into the field of view beneath the camera lens, and filmed reactions – mostly in real time – using custom-made high-resolution optics. The macro-photography required high intensities of light, often with depths of field measuring only fractions of millimeters.

Tom's starship enters the nebula, represented by wispy tendrils of golden gas and patterned after the Orion Nebula — observed by ancient Mayans as the enigmatic constellation 'Xibalba.' "We gravitated towards the Orion Nebula partly because it's so beautiful and relatively close to earth," stated Peter Parks. "There are others equally spectacular further out, like the Magellan Cloud or Eagle Nebula. Orion contains some extraordinary gaseous formations, such as the Horsehead Nebula, where the tips of a very dense cloud are backlit by luminous gases, which is truly spectacular. We referred to a book of Hubble telescope images and reproduced those, sometimes almost exactly."



The spaceship emerges from the densest portion of the nebula and rises past molten debris extruded from the dying star. Intelligent Creatures layered elements of Image Quest galactic fluid effects to create fields of expanding plasma, and added molten falling particles – called 'nuclear rain' – by extracting and emulating details from scans of the practical elements.

The nebula broke down into a series of environments. Distant views depicted the spherical ship ascending through golden arms of light, consisting of matter ejected from the dying star. The particles then gave way to a clearing known as ‘the bowl’ in the direct light of the star, five or six stops overexposed. “We had wispy micro-chemical reactions for the golden nebula arms,” noted Jamie Hallett. “We used denser cloud-like elements made out of yeast to construct the majority of the bowl, with wispy little strings for what almost looked like rain coming off the nebula arms. We pulled those elements, slowed them down, tracked them in and strategically placed pieces to create depth.”



Special effects supervisor Louis Craig of Les Productions de l'Intrigue provided mechanical effects, including hip-mounted wire-rig effects to emulate zero gravity, seen as Creo climbs the tree to move closer to Xibalba.

The ship’s vertical passage through frame was derived from the director’s shooting plan for orienting the camera in the circular spaceship set. “I was looking for a way to shoot in a room with no corners,” Aronofsky explained. “It became very complicated, especially when there was no gravity, and I decided to establish screen direction as up and down, as if the ship was rising like an elevator. And since the lead character always seemed to be charging somewhere in the story — as ‘Tomas’ in the jungle, or as ‘Tommy’ in the lab, moving left to right, or right to left — that created an x/y/z axis of left to right, front and back, up and down. So I decided to create order in that sphere with this cruciform style, shooting in a three-dimensional cross, and I followed that style through the film.”

The cruciform shooting style led to stylized, vertical whip-pan transitions connecting the three time-frames in the story, one following Tommy Creo’s car as he drives at high-speed through the night toward his research laboratory. “The idea for the vertical whip-pans came when I realized I had three similar moving shots,” recalled Aronofsky. “The first was in space, moving toward the nebula. It made sense to do a vertical whip, as opposed to a horizontal whip, following the ship. After that, I decided to change the other whip-pans, to much expense and difficulty! It was a lot harder to hang the camera 12 feet in the air and whip-pan with a car.”

The live-action whip-pan on the car was filmed in Montreal. “We had the camera up on a bridge at night,” said Jeremy Dawson, “and we had to brace a camera rig so it didn’t vibrate. It was hand-operated, because there was no other way to whip-pan fast enough with a speeding car, and the car didn’t look right unless it was traveling at 70 kilometers an hour. We rigged the camera upside-down on a spring-loaded mount. On ‘go’ the operator pushed the camera as fast as he could to hold the action. We then digitally re-created the skyline and straightened out the city on both ends. The real stuff was the road and the streetlights; everything else we tracked in with matte paintings.”

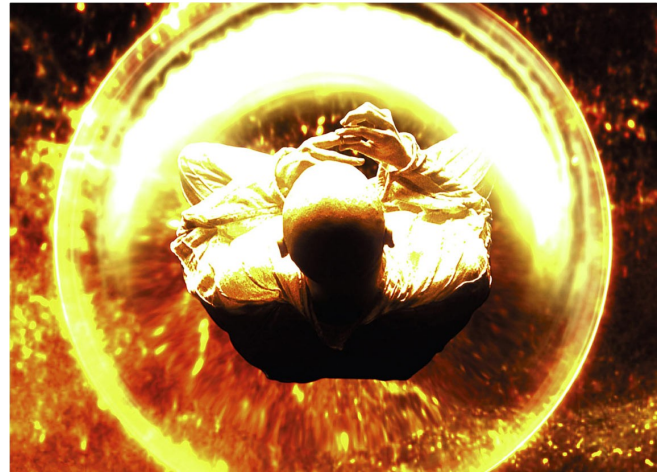
The final vertical-whip employed the same hand-operated camera rig following Tomas Creo on horseback, galloping beneath and then away from camera toward a distant castle beneath a glowering night sky — a Technicolor Creative Services digital matte painting by Jordan Nieuwland representing 16th-century Seville.

Inside the castle, Technicolor Creative Services also supplied a digital set extension for a scene in which Tomas meets Queen Isabella (Rachel Weisz) in her throne room, filmed on a soundstage in Montreal.

“James Chinlund built a beautiful throne room set,” remarked Dan Schrecker. “The setting was an endless row of pillars, filled with hundreds of votive candles in glass candelabras hanging by chains. We had a tracking shot of Tomas walking towards the Queen with candles passing in front of camera and behind Hugh. We had to extend the background as far as possible so that it looked like the columns went way back, further than the set, which was built right up to the studio walls.” Low-key atmospheric lighting and myriad reflective light sources made the use of greenscreen or bluescreen backgrounds impossible; instead, Technicolor Creative Services visual effects supervisor Phil Jones and lead compositor Jason Snea oversaw hand-tracking and rotoscoping of Jackman from the background and remapped pillars to extend the set digitally.

Narrative plotlines move toward simultaneous resolutions as Tom Creo arrives at the dying star, Xibalba, which he hopes will resurrect the dying tree inside his spaceship. Galactic fluid effects deep inside the nebula relied on imaginative interpretation. “Nobody really knows what it would be like to be flying through a nebula,” said Schrecker. “We wanted to be open to possibilities, and so we allowed ourselves scientific cheats in scale. The phenomena were so vast, we’d probably see nothing happening within a five-second shot, so we sped up the motion to make it more visually interesting.”

Image Quest shot nebula fluid effects in real time. Intelligent Creatures digitally manipulated the chemical reactions and developed a new look for Xibalba as Tom’s crystal sphere nears the dying star. “Stars give off shells of matter over millions of years,” explained Jeremy Dawson. “They spread out, creating an area of vacuum around the star, where material bunches up in ripples to create the outer layer around the star.” The visual effects team developed its own vocabulary to describe the phenomena exhibited in Peter Parks’ footage. “To create the effect of speed as objects pass by the ship, we used particles that we called ‘nuclear rain’ the closer we got to the star. I imagined this nuclear rain as little globs of molten lava. Another element was called ‘cancer,’ which related back to Tommy’s microscope images and his wife’s disease. Peter Parks filmed an element at the end of



Encapsulated within a smaller sphere, Creo floats to the top of his spacecraft, folds into lotus position and communes with Xibalba outside the ship. Hugh Jackman trained for months to master complex yoga moves in apparent zero gravity, achieved using an Intrigue rig resembling a hand-cranked rotisserie operated underwater in a swimming pool. Using the underwater photography, filmed against a brightly lit white screen, Intelligent Creatures blended elements into plates with sphere deformations, subtle reflections and refractions.

certain reactions, where chemicals broke apart into really beautiful fractal webs. We used those within the nebula; so as we got closer to the dying star, it disintegrated into this cancer.”

Intelligent Creatures layered expanding plasma and nuclear rain with digital enhancements. “We heavily treated nuclear rain to make it feel like falling, burning gases,” noted Jamie Hallett. “We matched Peter Parks’ nuclear rain as closely as we could, and then used 3D elements to give us control of one or two hero particles — so it was very subtle. We were always accenting filmed environments, strategically placing particles to add depth.”

Tom Creo climbs the tree in the center of his ship and, part-way up, enters zero gravity, floating into lotus position inside a smaller one-man sphere that he uses to commune with Xibalba outside the ship. Aronofsky shot Jackman ascending the tree assisted by a flying wire rig mounted at the performer’s hips. Jackman assumed lotus position in an underwater rig, which Intelligent Creatures then composited with animated protective spheres. “We had a top shot looking down on Hugh,” said Jamie Hallett. “He floated towards the top of the sphere and then became encapsulated in a smaller sphere that wrapped around him and pulled away, leaving tiny bubbles beneath it. Darren wanted the effect to be as real as possible, so we didn’t go crazy with fluid animations. We generated a deformation of a sphere with very subtle reflections and refractions.”

Rising toward Xibalba, Tom greets the star as it erupts, radiating plasma that blasts away his clothing. Jackman first performed his reaction to the explosive event underwater, unfolding from lotus position, and then repeated the move suspended against greenscreen in an Intrigue Effects rig. “The rig was genius,” commented Jeremy Dawson. “They gave him seamed clothes rigged with wires on the greenscreen stage. We put the camera behind him and, on action, they ripped off his wardrobe in about eight frames.”

Intelligent Creatures blended the underwater element into the wire rig shot, removed the wires and harness with a white lumakey, and enhanced the in-camera overexposure as Xibalba exploded. “We spent months building that explosion,” remarked Raymond Gieringer. “Each ring was a different scan of a Peter Parks element, with micro



Tomas emerges from an antechamber in the Mayan pyramid to a plaza where the Tree of Life is alive in all its former glory. Aronofsky photographed Hugh Jackman advancing into a greenscreen cove.



Mokko Studio composited the element into a matte painting that depicted tropical rainforest stretching out in all directions below a shallow pool of water around the tree. The shot included digital water simulation of the pool

details built into each ring. It was like building a mountain range. We started with broad strokes of larger elements, and then took smaller pieces and kept enhancing here and there until the mountain range had scale and form.”

around Tomas, and a New Deal Studios miniature element of the tree, built at 1/6-scale and filmed at high speed to simulate gently moving foliage.

Intercutting Tom’s transcendence in space, Tomas Creo fights the Lord of Xibalba in the Mayan pyramid and briefly appears as his future self, floating in a transcendental state, suspended in midair — an underwater element of Jackman in lotus position composited with a greenscreen face replacement tracked in with the eerie fluid motion of his clothes.

Wounded by a sword blow to his abdomen, Tomas emerges from the temple antechamber to a stucco plaza on top of the pyramid, where rainforest stretches out in all directions beneath a shallow pool of water and a giant tree — the *Tree of Life* from the spaceship, alive in all its former glory. Aronofsky filmed Jackman advancing into a greenscreen cove. Mokko Studio composited the element into a digital matte painting that included a partial set of a portion of the pool, a low retaining wall, the tree trunk and the lowest level of the tree’s canopy backed by a painted backdrop. “We ended up mostly replacing the backdrop,” said Jeremy Dawson. “Look Effects added moving clouds for closer shots with Hugh under the tree. Mokko Studio did the big reveal and wide shot using digital matte paintings. We had a little bit of water on set; but where Hugh was walking, it was CG water. In all the wide shots we used a miniature tree.”



Tomas experiences the restorative power of the tree by applying its sap to a wound and ingesting the substance, causing flowers to burst from his body. Maestro Studio – with digital assistance from Buzz Image Group – created erupting flowers as mostly practical effects. Employed in some shots was a replica of Hugh Jackman’s body, loaded with pneumatic bladders containing flowers, which was blended at the neck while the actor reclined on a slant board beneath the elevated set.

New Deal Studios built the miniature *Tree of Life* utilizing techniques similar to the withered version, matching the trunk and canopy to the full-scale set, and extended the tree above to resemble a verdant oak. Modelmakers built the tree at 1/6 scale, resulting in a 12-foot-tall, 18-foot-wide articulated miniature. “Jeremy and Dan wanted the branches to have movement and weight,” stated Matthew Gratzner. “We used a very simple steel tube armature in the tree that had enough structural integrity but was thin enough to flex so it could move with correct scale weight. We then added a mix of sculpted and real branches, purchased about 20,000 strands of tiny artificial leaves pre-wired to little sprigs, and hand-wired the sprigs to every branch, sub-branch and twig.”

For the pullback revealing the *Tree of Life*, modelmakers dressed the miniature into a 12-foot-square tabletop terrain against bluescreen and rigged air movers to ripple foliage. Tony Cutrono employed New Deal’s Cruciflex rig to shoot high-speed motion control, the camera retreating rapidly from the tree, shooting at 36 and 48 frames a second. A separate pass used mylar to capture the tree’s reflection in the surface of the pool.

Realizing he has found the legendary *Tree of Life*, Tomas stabs the tree with his dagger and witnesses the magical restorative effect of its sap, which causes flowers to burst from the ground and then, as Tomas ingests the liquid, from his own body. To shoot the surreal sequence — based in part on a Mayan creation myth — Intrigue rigged the prop tree to leak sugar water representing thick white sap. Maestro Studio then collaborated with Buzz Image Group, in Montreal, to create the erupting flowers as mostly practical effects.

“I am not anti-computer animation,” asserted Darren Aronofsky. “But I tend to shy away from 3D effects. That was very challenging with the flower sequence because the most obvious solution there was CG. There was a lot of pressure from the visual effects department and producers to go the CG route, because CG has been doing growing tree effects for a long time. But I wanted this to feel completely different from anything I’d seen. So we used a practical effects rig, and pushed it as far as possible. Even though it was more restrictive on set, I enjoyed those limitations because they gave us an effect that interacted with the actor. It created its own reality.”



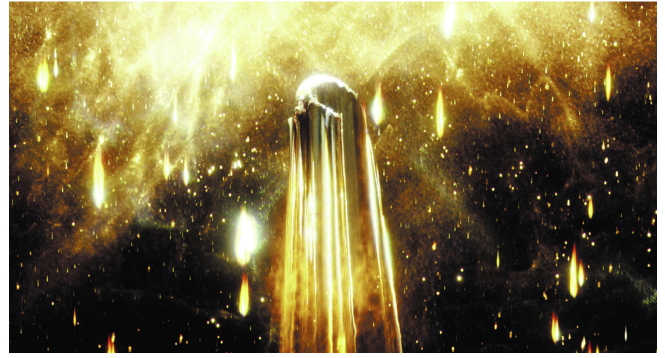
Maestro founder Adrien Morot details a likeness dummy head used for closeups of blooms exploding from *Creo*'s mouth. Buzz Image added writhing digital roots and unfurling flowers animated to resemble time-lapse photography.

The first practical tests for the flower sequence included Image Quest time-lapse flowers shot digitally in daily blooming cycles. The footage served as reference for Buzz, which developed digital animation while physical effects continued to search for practical alternatives. “Darren asked me if I had any ideas,” said Adrien Morot. “I immediately thought of a technique I had learned while working with my longtime hero, Steve Johnson, on *Species* and *Lord of Illusions*. Steve and his lead artist Bill Bryan perfected a way to create erupting tumors using little plastic bags, squashed down into small cavities, that inflated into much larger volumes. We did some tests using a chest cavity loaded with plastic bags and, for an effect where flowers grow out of the mouth, built another rig with a tube feeding into my assistant’s mouth from which a bag grew out. We videotaped that test and showed it to Darren. His first reaction was to laugh — ‘Oh my god! That’s so violent!’ CG tests just hadn’t had the impact of interacting with the mouth and pushing out the cheeks.”

The video test prompted months of further effort to establish the look of flowering plants, eventually accomplished with silk flowers, leaves and stems resembling impatiens. Maestro built a neck-down photorealistic prosthetic dummy of Hugh Jackman from lifecastings of the actor, made a fiberglass core with jointed articulated legs, and fitted the hollow chest cavity with 150 pneumatic greenery bouquets. Nelson Da Costa rigged bladders with a network of tubing attached to air compressors that propelled greenery through pre-scored silicone skin in a choreographed pattern. “Darren wanted flowers to bloom in sequence,” commented Morot. “They started in the center of the chest, where the knife wound was, then expanded in rippling effects out across the body onto the terrain.”

Jackman enacted the scene, collapsing in agony, at which point he lay beneath the elevated set, his body on a slant board, his arms, shoulder and head visible to camera, the prosthetic body blended to him at the neck. Four operators controlled air bladders; while six others controlled legs, torso and breathing actions from beneath the set. Jackman also wore an oral prosthetic, with a stainless steel tube fitted inside his mouth, which propelled folded air bladders from the back of his throat, pushing an explosion of flowers out from his mouth.

Insert shots of flowers tearing through Tomas’ skin required a delicate skin formulation. “Rubber or pre-scored silicone don’t rip like real skin,” noted Morot. “For two months we tried to come up with different formulas for realistic ripping skin, adding water to urethane to make it weak, for example; but nothing really worked. One day I was driving to the set, coming to show Darren yet another flower test, and I had a flash of inspiration, remembering how gelatin prosthetics decay with sweat.



Xibalba explodes and immolates Tom Creo, causing his body to atomize into plasma that rejuvenates the Tree of Life. Giant Killer Robots joined the project during the final weeks of postproduction to generate Xibalba energy-impact shots, which required close collaboration with the visual effects supervisors and Aronofsky to define abstract concepts. The sequence included wire-flown effects of Hugh Jackman suspended against greenscreen, a digital double built to deform in ways impossible to achieve with the actor, a 3D model of the Tree of Life built to enable complex lighting and fluid interactions, and practical and procedural fluid effects.

I immediately pulled over to the side of the highway and went into my trunk where I had some gelatin appliances. I licked one of those appliances, and it shredded into a million holes!”

To film the effect, Maestro cast gelatin skin a quarter of an inch thick, painted green on the inside and natural skin color on the exterior, stretched the skin over a hollow fiberglass form, then pumped salt water through holes on the reverse and corroded the gelatin in an organic eroding effect. The production also filmed blooming flowers as bluescreen insert elements, which Buzz used to complete the effect with subtle CG additions at the climax of the scene as the camera rose, in a motion control move, flowers engulfing Tomas.

Buzz visual effects supervisor Louis Morin accompanied the shoot, then digital artists enhanced plates to fill out areas of growth. “Dan and Jeremy wanted to keep the energy of the flowers ripping clothes and skin,” stated Buzz Image Group CG supervisor Pierre-Simon Lebrun-Chaput. “We first composited all of the elements together and made a layout for the greenery. Most of it was shot live, but we added to every shot and sometimes tweaked timings of flowers popping out. We hand-tracked some of the live rigs that were shot on the bluescreen and matched them to the live-action, adding leaves here and there to cover holes and add depth.”

To accentuate flower detail, Buzz added CG blooms using live impatiens as reference for high- and low-resolution models built in Softimage Xsi and rendered in mental images’ mental ray. Artists scanned live petals, hand-painted textures and developed a complex lighting rig to simulate translucency and light reflectance. An animation rig controlled growth and motion of large quantities of blooming plants, while allowing flexibility to add subtleties and variations.

Lead animator Phillipe Sylvain created a dozen keyframe animation growth cycles, from which production selected five flowering patterns to populate shots. “They wanted it to feel like stop-motion or a time-lapse effect,” related Lebrun-Chaput. “Once we decided which blooming pattern we wanted for a specific flower, we added subtle keyframe jitter to the petal motion to simulate time-lapse. We learned a lot from Peter Parks’ footage and from plant growth research on the Internet.” For the final pullback of Tomas swallowed up by flowers, practical growing plants covered 20 percent of Jackman’s body and set the rhythm for the shot. 3D artists then added elements in Discreet Flame and Inferno, and compositors layered growth on Tomas’ arms, legs and head in Apple’s Shake.

Back in space, the full force of Xibalba’s energy impacts Tom Creo and his ship, causing the withered tree to regenerate as the *Tree of Life*. The sequence required intense conceptual development to define abstract visual concepts. “We were trying to figure out what would be a good inspiration for the sequence,” recalled Jeremy Dawson. “Darren wanted Hugh to look like he was being blown with energy and smeared across the screen. He ended up referring to ‘WK Interact,’ a graffiti artist whose work we had all seen on the sides of buildings around New York. The artist used a simulation of speed, like a futurist graffiti, where a roller-skater had trippy, organic streaks coming off him.”

Giant Killer Robots joined the project in the final weeks of postproduction to generate five Xibalba energy-impact shots, which required considerable technical and creative resources. “It was a mixture of illustration and artistry,” said GKR visual effects supervisor Peter Oberdorfer. “In past

projects, we've applied this much research into 200 shots. This took the same level of development for essentially one effect. It required a very progressive dialogue with Jeremy, Dan and Darren. We threw around a lot of ideas using many crazy practical, CG and procedural effects."

The sequence began with a practical element of Jackman suspended on wires, which GKR used for closeups as Xibalba's energy hit Tom in closeup, burning off his skin. To simulate peeling skin, GKR digitally tracked the surface of Jackman's face with a CG surface, projected the photographic texture back onto the surface and then stripped away layers, revealing internal luminescence. "Darren didn't want it to be gruesome," said Oberdorfer. "We wanted Tom to be filled with beauty as he began to meet his death."

Cutting wide, Tom's dissolving body streams down onto the tree. GKR used a digital double to represent Jackman's extreme body deformation and built a 3D digital model tree, referencing a brightly lit, locked-off shot of the 1/6-scale miniature tree, using L-systems to organically model branches that matched the practical element. "We rendered the CG tree with heavy frame buffers so we could have control over different lighting passes in the composite," said Oberdorfer. "The tree was dead at the beginning of the shot. Tom's life essence spread down almost like a spiritual fertilizer that seeded the tree — so, by his sacrifice, the tree regained its life. It was very, very 'out there.'"

GKR rendered traces of Tom's body breaking into liquid plasma that impacted the tree, causing its rejuvenation amid a shower of cosmic particles. The shot required 70 layers of holdout mattes incorporating practical fluid elements mixed with a witches' brew of 3D elements. For top-down views of Tom's body streaming energy, GKR mapped liquid elements onto concentric cylinders descending around Jackman. Other shots utilized floating glowing liquid particles sampled from practical plates, projected as sprites. In more detailed interactions, fluid simulation effects emulated the scale and motion of practical effects. "When the plasma hit the tree and started to break up," said Oberdorfer, "or when it had to ooze over Tom's body, we couldn't just use a pre-canned element. We used Peter Parks' elements as an emitter based on its luminance, extracted the motion, then put that into a fluid field, and it took on a life of its own."

To choreograph the rejuvenation of the *Tree of Life*, GKR developed a gray model 3D animatic that illustrated Tom's body position, the rotation of the tree, and the growth of leaves and branches. This became a template to build the shot as a ray-traced Xsi and Maya model with translucency and self-shadowing in foliage, rendered in layers to allow flexibility for lighting changes and color timings in the Shake composite.

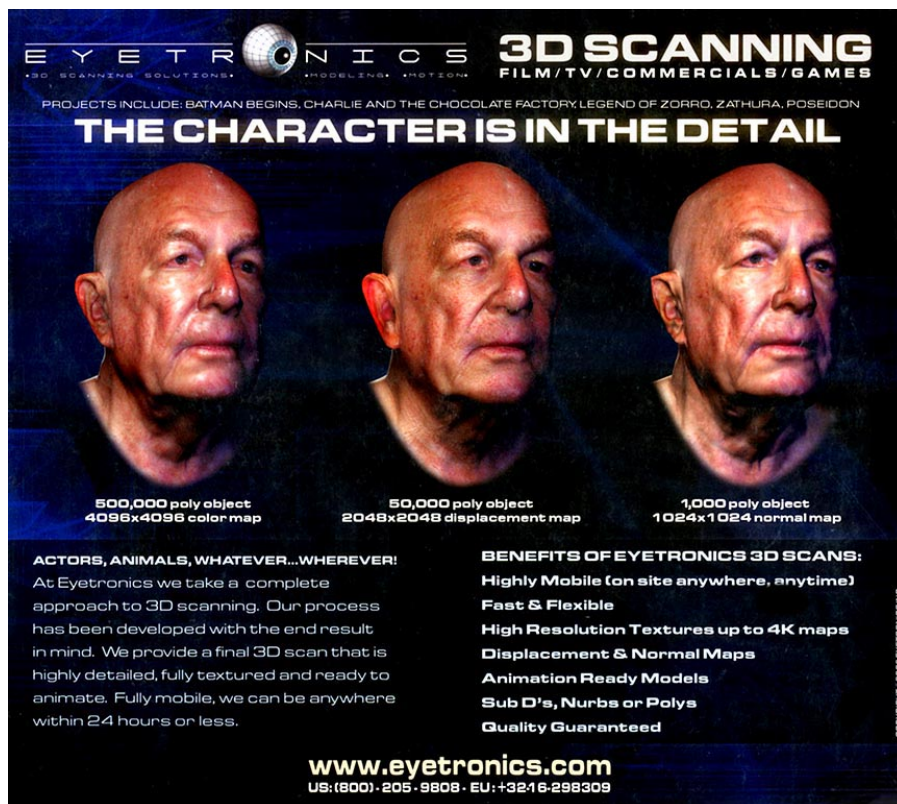
The cosmic rebirth transitions through a whiteout to snowbound tree branches in present day for the final sequence, in which Tommy Creo comes to terms with losing the love of his life — leaving viewers to contemplate if the journey into space was literal, or a journey into Tommy's mind. "We left it open," said Aronofsky. "It was something that we wanted people to think about. We were happy that it could work in many different ways."

The haunting and introspective nature of the film required a leap of faith for many of the artists involved in the creation of the visual effects. "There was a lot of high concept behind the imagery," observed Jeremy Dawson. "For Darren, every emotional realization had to have a visual manifestation. We invited him up to Intelligent Creatures a couple of times to meet the artists; and

later, as we went through shots, he could tell which artist did what shot. It's not always easy to find people who can bring that to a project, to get so emotionally into it they feel it's their shot."

The wealth of creativity ultimately outweighed financial constraints imposed by the downscaling of the project. "You can't really create in a world of infinite possibilities," stated Darren Aronofsky. "You have to have limitations. Outside of the physical limitations of what is possible with filmmaking — what a dolly can do, what a crane can do, how film can be exposed — the limitations of a budget help a filmmaker figure out how best to tell his story by getting the most possible, within the budget, onto the screen. I think there will always be big-budget 'event' movies that people will want to stand in line to see on opening day and experience with a packed house on a big screen. When Jim Cameron comes out with his next opus, I'm taking off work and I'm going to a matinee with everyone in my company! But I think there will also always be a billion independent films among the 'tentpoles' every year. Films that depend on effects alone are not going to fly. That's been shown a lot, I think, this summer. You've still got to tell great stories."

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